Capital taxation, long-run growth, and bequests

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Abstract

It has been shown that higher capital taxes can have a growth-enhancing effect when combined with a revenue-compensating cut in wage taxes or with an expansion in productivity-increasing public services. The present paper demonstrates that these results critically hinge on the existence of a bequest motive. It is shown that a wage-tax cut is no longer growth-enhancing when bequests are operative. By way of contrast, increasing productive public services may well boost growth. The theoretical findings are illustrated by numerical simulations based on US data.

Keywords capital income taxation, public spending, overlapping generations, growth, family altruism

JEL-Classification D64, D91, H24, H50, O40,

1. Introduction

1.1. Overview

Over the last decades there has been a long-lasting debate in the empirical and theoretical economic literature on whether, and if so how, fiscal policy affects economic growth. Numerous papers have analyzed the effects of taxation, transfers, spending, and other actions related to fiscal policy on economic

performance. There are at least two things that can be concluded from these studies: First, fiscal policy does affect economic growth. Second, the extent and the direction of the concrete policy at hand generally depend on the specification of the model. Concerning taxation of income, especially from capital, it is, however, commonly believed that there is an adverse effect on growth. Models analyzing the equilibrium relationship between capital income taxes and growth typically find that an increase of the capital income tax reduces the return to private investment, which in turn implies a decrease of capital accumulation and thus growth (Lucas, 1990; Rebelo, 1991). Besides these positive studies, there also exists a huge body of literature dealing with normative effects of capital income taxation, originally triggered by Judd (1985) and Chamley (1986), who find that capital taxation decreases welfare and a zero capital tax is thus efficient in the long-run steady state.

In some theoretical work, however, provocative evidence is put forward that capital income taxation may increase growth (Uhlig and Yanagawa, 1996; Rivas, 2003). Time series of capital income tax rates and personal savings in the US, for instance, seem to be positively correlated in the long run, suggesting that the conventional wisdom of low capital taxes fostering growth is less clear cut than had been proposed by most preceding theoretical studies.

Yet, an important deficiency of these studies is the absence of intergenerational transfers in form of bequests. The importance of such transfers for capital accumulation has been documented by several papers; see for instance Kotlikoff and Summers (1981, 1986) and, more recently, DeLong (2003, Fig. 2-1).

These studies confirm a significant influence of bequests on capital accumulation and growth. What they cannot reveal, however, is the actual individual motive for leaving bequests.[2] Most of the existing literature models that motive by assuming that individuals take into account the infinite stream of descendants' utilities as in Barro (1974). Within such a setting, various authors have

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[2]For a comprehensive survey of different altruistic bequest motives see Michel et al. (2006).

shown that capital income taxation typically translates into lower growth[3]. The main criticism of Barro's approach is that a whole dynasty behaves as one decision unit having perfect foresight about the indefinite future.

Alternatively, individuals may be assumed to have a joy-of-giving bequest motive (Andreoni, 1989). In this case, the time horizon is finite, but the magnitude of transfers is independent of the descendant's well-being, and thus capital taxation may have a positive effect on growth under similar conditions as in Uhlig and Yanagawa (1996). In this paper, however, I adopt the family altruism model, which allows us to work with a finite planning horizon and, at the same time, leaves the bequest motive sensitive to the offspring's economic situation (Lambrecht et al., 2005, 2006; Bréchet and Lambrecht, 2009). Within such a setting, parents are concerned about the disposable income of their immediate descendants and not about the use of this income.[4] Consequently, the disposable income of the children (not their utility) becomes an argument of the individual's utility function. Empirical evidence for the family altruism model is provided by Laitner and Justner (1996), who find that the amount of households' bequests is largest for those with the lowest assessment of children's possible earnings.[5] Altogether, such a specification is clearly more general than the joy-of-giving approach and seems to be more realistic than Barro's model.

In the next section, I incorporate the family altruism motive into an endogenous growth model in order to study two important fiscal policies. Firstly, I reexamine the effect of capital income taxation on long-run growth if inter-

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[3]This kind of model is formally equivalent to one assuming a representative and infinite-lived agent; see, again, Lucas (1990) and Rebelo (1991).

[4]This formulation originally goes back to Becker and Tomes (1979), who assume that parents care about the quality or the economic success of their children as measured by the children's lifetime income. Such an approach has also been used in growth models with human capital; see, e.g., Glomm and Ravikumar (1992), in which preferences depend on the quality of schools, which in turn are directly related to the disposable income of the children. See also Grüner (1995).

[5]See also Mankiw (2000), who argues that neither the Barro model nor the pure life-cycle model is suited to analyze fiscal policy. This is due to three important observations: First, in reality consumption smoothing over time is not as perfect as both models predict. Second, there are a lot of households near zero wealth for which saving is not a normal activity. Third, the life-cycle model cannot account for the importance of bequests in capital accumulation.

generational transfers within the family are operative. Secondly, I study how the composition of government spending affects the growth rate. The model describes a unified framework comprising the results found by Uhlig and Yanagawa (1996) and Rivas (2003) as special cases whenever intergenerational transfers are inoperative and the government uses additional tax revenue from capital taxation to either reduce the tax burden on labour income or enhance productive government spending.

Endogenous growth in this model is generated by a positive externality of a fraction of total government spending that affects private investment and bequest decisions. This type of spending is referred to as public services (or productive spending, as above) and captures expenditures on the stock of a country's infrastructure, including, e.g, highways, hospitals, and communication systems.[6] The government decides about the fraction of total outlays allocated to either productive spending or usual government consumption that do not affect productivity. Furthermore, public services are assumed to be provided without user fees, and, for reasons of simplicity, the issue of congestion is ruled out.

It turns out that the results critically depend on how the government uses the additional tax revenue resulting from an increase of the capital income tax. Growth unambiguously declines in the presence of intergenerational transfers if expenditures are fixed and revenue from capital income taxation is used to cut labour taxes, but may increase if public services are enhanced instead. Finally, the impact of changing the composition of total spending in favor of government consumption on growth is clearly negative. These results are generally driven by three channels: First, they depend on how savings react to changes in long-run interest rates. Second, they depend on the mechanism of income redistribution, which is either a shift of the tax burden across generations or a shift in factor productivity. Third, the possibility of redistributing income within the

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[6]For a recent review of the role of public spending in endogenous growth theory see Minea (2008).

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family as a reaction to a change in the tax structure matters. Numerical results reveal realistic parameter constellations in which growth increases if income is redistributed through an increase in total factor productivity.

The idea that public spending may have a positive effect on growth has received much attention in both the empirical and the theoretical literature. Following the pioneering work of Aschauer (1989), many empirical studies confirm the result that public investment positively affects the return to private capital and thus private investment (e.g., Easterly and Rebelo 1993; Gramlich 1994; Morrison and Schwartz 1996)[7]. On theoretical grounds, much of the literature follows the seminal work of Barro (1990), who establishes productive government services to be one important source of sustained endogenous growth. In these models, the relation of income taxation and growth is usually nonlinear, depending on the initial level of taxation. Yet, in those papers the analysis is conducted within a representative, infinite-lived agent model and is thus not able to capture the impact of taxation on life-cycle savings and intergenerational transfers within the family.

Finally, this paper also addresses the welfare implications of the model which is of special importance in determining the political support for any of the above mentioned policy reforms. By analyzing the welfare effects for the currently young and old generation, we find that when bequests are inoperative, positive growth effects are accompanied by a welfare gain for the economy if the level of capital income taxation is not too high. By contrast, in case of operative bequests, the welfare effects are generally ambiguous depending on the relative strength of the effects of fiscal policy on growth and interest rates. However, a shift of government expenditures in favor of government consumption clearly reduces not only growth but also welfare irrespectively of bequests being operative or not.

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[7]Note, however, that some studies either face difficulties in isolating a positive effect in cross section data or even report a negative relation of government spending and growth in that high spending may decrease income, e.g. Agell et al. (1997) and Evans and Karragas (1994).

1.2. Related Literature

From a technical point of view, there are a lot of studies that examine the relation of capital taxation and growth in the presence of bequests and then distinguish the two cases of operative transfers and bequest constraints (see, e.g., Ihori 1997; Caballé 1998). In general, these studies find negative (or no) growth effect if bequests are operative, depending on how the additional revenue from increased taxation is used. In a pioneering paper, Caballé (1998) shows that the presence of intergenerational transfers may reverse the relation between capital income taxation and growth: If bequests are inoperative, an increase in the capital income tax may have a growth-enhancing effect, provided that the elasticity of intertemporal substitution is sufficiently low. Yet, in case of operative bequests, the economy behaves dynastically and a zero tax rate would be optimal from a growth- (and welfare-) maximizing point of view. However, the modeling of the bequest motive in this paper is in contrast to most of this literature and it is a priori not clear if the results also hold in the framework of the family altruism model.[8] So far, there have only been a few papers dealing with intergenerational transfers *within* the family: Lambrecht et al. (2005) analyze the effect of public pensions on growth when altruistic parents can affect their children's income through investment in education and by leaving bequests. It turns out that an increase in the pension level is bad for growth, in that it distorts the decision between bequest and education in the case of inoperative bequests. Lambrecht et al. (2006) study different fiscal policies within a neoclassical framework. They find that a pay-as-you-go pension scheme has no effect on the intertemporal equilibrium, whereas public debt is not neutral, because private intergenerational transfers cannot neutralize public intergenerational transfers induced by public debt. Finally, Bréchet and Lambrecht (2009) examine the interplay between population growth and the use of natural resources, which can either be used in production or bequeathed

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[8]Note that when bequests are operative in this framework, the economy will not behave dynastically as in the standard Barro model. Rather, each family forms a distinct decision unit, having a finite time horizon (Lambrecht et al., 2006).

to the children. They find that the strength of the bequest motive is crucial in determining the role of resource preservation as a reaction to demographic shocks.

The most closely related studies are Uhlig and Yanagawa (1996) and Rivas (2003); also, Aschauer (1989) and Morrison and Schwartz (1996) provide empirical evidence for some of the results concerning the role of productive government spending. Moreover, the specification of the family altruism model can be justified by the empirical findings of Laitner and Justner (1996) and Mankiw (2000).

Uhlig and Yanagawa (1996) set up an overlapping-generations model in which endogenous growth is generated by a positive externality—viz., technological spillovers in production, across firms. Moreover, government expenditures are assumed to be a fixed fraction of output, being financed by proportional taxes on wage and capital income. As labour income accrues mostly to the young generation and capital income to the old generation, a shift of the tax burden from wage to capital taxation may then increase growth if the interest elasticity of savings is sufficiently small.[9]

Rivas (2003), by contrast, presents an overlapping-generations model in which sustained growth is ensured by public investment in a country's infrastructure, i.e., productive government spending. In fact, this is a different source of externality in production that is capable of generating endogenous growth. This model explicitly takes into account the composition of total government outlays: Tax revenue can be allocated either to government consumption, to public services, or to transfers.[10] Rivas shows that within such a setting in-

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[9]In a recent contribution, however, Ho and Wang (2007) show that the relation between capital income taxation and growth is non-monotonic if capital accumulation is subject to the adverse selection problem in the credit market. More specifically, if risk types of borrowers are unknown to lenders, capital taxation worsens the adverse selection problem, thereby inducing an additional negative effect on growth that diminishes the positive effect stemming from a shift of the tax burden across generations.

[10]Note, however, that if government expenditures are fixed, a shift of the tax burden from the young to the old as in Uhlig and Yanagawa (1996) is then capable of generating their positive-growth result. In this case the two models are formally equivalent and the only difference is the source of sustained growth.

creased capital taxation may enhance growth if, again, the interest elasticity of savings fulfils some restrictions. Yet, the result does not require a shift of the tax burden, but stems from the effect of taxation on factor productivity, which constitutes an alternative channel for redistributing income among generations.

Consequently, these studies indicate that the actual mechanism of direct or indirect income redistribution across generations matters in determining the outcome of capital taxation on growth. By allowing for intergenerational transfers within the family, this paper adds an alternative private redistribution channel to the analysis and then reexamines the effect of capital taxation on growth. Interestingly, it turns out that the latter channel offsets the income redistribution induced by the shift of the tax burden but cannot (totally) compensate intergenerational redistribution induced by changes in total factor productivity. By contrast, in the latter scenario, positive growth effects are obtained under weaker assumptions than in the case when intergenerational transfers are absent.

The remainder of this paper is organized as follows. Section 2 presents the basic model. The intertemporal equilibrium for this economy is defined, and it is shown that such an equilibrium is characterized either by operative or by inoperative bequests. For both cases the growth effects of capital taxation are determined. Further, the impact of an increase in government consumption on growth is analyzed. In the last subsection, the model is calibrated using US data, and the numerical results are presented. Section 3 concludes.

2. The model

The basic framework is an overlapping-generation model in the tradition of Diamond (1965), in which parents have an altruistic concern for their children. In contrast to most of the existing literature, this concern is modeled by providing children with a disposable income later on in life, i.e., the disposable income of the child becomes an argument of the individual utility function (Lambrecht et al., 2006). Moreover, markets are competitive, and the size of

population is assumed to be constant. The government collects taxes and allocates the revenue to either productive government spending or nonproductive government consumption. This setup is capable of generating an endogenous growth process in line with Barro (1990).

2.1. Firms

On the production side of the model, perfect competition between a large number of identical firms is assumed. A representative firm in period t produces a homogenous output good according to a Cobb–Douglas production function with capital K_t and homogeneous labour L_t as inputs:

$$Y_t = AK_t^\alpha (G_t^s L_t)^{1-\alpha}, \tag{1}$$

where $1 > \alpha > 0$ is the share parameter of capital, $A > 0$ is a general index of efficiency, and G_t^s denotes the flow of aggregate government services.

Each firm maximizes profits under perfect competition, implying that, in equilibrium, production factors are paid their marginal products:

$$w_t = (1-\alpha)AK_t^\alpha L_t^{-\alpha}(G_t^s)^{1-\alpha} \tag{2}$$

and

$$r_t = \alpha AK_t^{\alpha-1}(G_t^s L_t)^{1-\alpha}. \tag{3}$$

Clearly, an increase of the amount of government services G_t^s exerts a positive externality on each firm's output, since producers take G_t^s as given when maximizing profits. This in turn enhances the productivity of labour and capital. The specific form of the technology exhibits increasing returns to scale in labour, capital, and government expenditures taken together. However, as will be shown below, there are constant returns at the aggregate level, which enables one to analyze the long-run growth effects of policy changes without transitional dynamics.

Due to the specification of the production technology, the model features scale effects. Yet, as population size is assumed to be constant, these effects, and also those of congestion (see, e.g. Barro and Sala-i-Martin 1992; Glomm

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and Ravikumar 1998), are excluded from the analysis. More specifically, the assumption that the aggregate flow of government services (instead of the per capita flow) enters the production technology implies that public services are nonrival and nonexcludable.

2.2. Government

The government balances its budget in each period t. Revenue is generated by proportional taxes on wage income, $0 \leq t^w \leq 1$, and interest income, $0 \leq t^r < 1$,[11] in order to finance the amount of total government spending G_t in period t. Total spending can be decomposed into a fraction $0 \leq \phi < 1$ of government consumption, denoted G_t^c, and a fraction $1 - \phi$ of productive government services, denoted G_t^s:

$$G_t = G_t^c + G_t^s. \tag{4}$$

Such a specification allows one to study the effect of a change in the composition of total government expenditures on long-run growth. It is further assumed that total expenditures are a fixed share of national output, i.e., $G_t = \kappa Y_t$, where κ is the government-spending–output ratio. A balanced budget, thus, requires

$$t^w w_t L_t + t^r r_t K_t = \kappa Y_t. \tag{5}$$

2.3. Consumers

At each period in time, there exist a number of young (N_t) and a number of old individuals (N_{t-1}). The population is assumed to be stationary. When young, each individual inelastically supplies one unit of labour and receives the net wage $(1 - t^w)w_t$. She also receives a nonnegative bequest, b_t. Income is spent on consumption c_t and savings s_t:

$$I_t \equiv (1 - t^w)w_t + b_t = c_t + s_t. \tag{6}$$

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[11] In order to generate sustained long-run growth, the interest rate must be positive. This restricts the capital income tax rate to be smaller than one.

When old, each individual allocates the return to savings $(R_{t+1}s_t)$ to second-period consumption (d_{t+1}) and to a nonnegative bequest to the offspring (b_{t+1}). The second period's budget constraint is thus

$$d_{t+1} = R_{t+1}s_t - b_{t+1}, \tag{7}$$

where $R_{t+1} = (1 - t^r)r_{t+1}$ is the total private return to savings or the gross interest factor after capital tax between dates t and $t + 1$.[12] The economy is called *bequest-constrained* if $b_{t+1} = 0$, and bequests are *operative* if $b_{t+1} > 0$.

Individual preferences are of the CES type and depend on first- and second-period consumption and on the disposable income of the children:

$$I_{t+1} = (1 - t^w)w_{t+1} + b_{t+1}. \tag{8}$$

Consequently, the life-cycle utility function of an individual born in t is

$$U(c_t, d_{t+1}, I_{t+1}) = \frac{c_t^{1-1/\sigma} - 1}{1 - 1/\sigma} + \rho \left[\frac{d_{t+1}^{1-1/\sigma} - 1}{1 - 1/\sigma} + \lambda \frac{(I_{t+1})^{1-1/\sigma} - 1}{1 - 1/\sigma} \right]. \tag{9}$$

This specification allows one to explicitly study the effects of a varying degree of altruism captured by the parameter $\lambda \geq 0$. Here $\rho > 0$ is a discount factor, and $\sigma > 0$ the intertemporal substitution elasticity.

Each individual maximizes the utility (9), subject to the constraints (6), (7), (8) and to the nonnegativity of bequests $(b_{t+1} \geq 0)$, by choosing c_t, s_t, d_{t+1}, and b_{t+1}. The first-order conditions of this maximization problem are

$$d_{t+1} = (R_{t+1}\rho)^\sigma c_t \tag{10}$$

and

$$d_{t+1} \leq \left(\frac{1}{\lambda}\right)^\sigma I_{t+1} \quad (= \text{if } b_{t+1} > 0). \tag{11}$$

The first equation is the standard condition over the life cycle, determining optimal savings. The second one gives the optimal amount of bequests. Bequests are positive if the marginal utility from old-age consumption equals the marginal utility from leaving the bequest.

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[12]For reasons of simplicity, we assume that capital depreciates completely.

Solving equation (10) subject to the budget constraints (6) and (7), the optimal savings function is found:

$$s_t = \psi(R_{t+1})I_t + (1 - \psi(R_{t+1}))\frac{b_{t+1}}{R_{t+1}}, \tag{12}$$

where $\psi(R_{t+1}) = (R_{t+1}\rho)^\sigma/[R_{t+1} + (R_{t+1}\rho)^\sigma]$ is the saving rule. From equations (11), (8), and (7) one obtains the optimal amount of bequest:

$$b_{t+1} = \frac{\lambda^\sigma}{1 + \lambda^\sigma}R_{t+1}s_t - \frac{1}{1 + \lambda^\sigma}(1 - t^w)w_{t+1}. \tag{13}$$

Individual savings depend positively on the disposable income and the amount of bequest transferred to the descendant. In turn, optimal bequests are positively related to individual savings, but decrease with increase of next period's net wage.[13]

2.4. Intertemporal Equilibrium

In a competitive equilibrium, firms' profits will be zero, and profit maximization implies that each firm equates, for a given amount of productive government spending G_t^s, the rental and the wage rate to the marginal products of capital and labour, respectively (equations (3) and (2)). Consequently, each firm chooses the same capital–labour ratio. With these facts, it is easy to obtain the share of national output spent by the government, i.e., κ, as a weighted average of the tax rates: Insert the equilibrium factor prices into the government's budget constraint, equation (5), and rearrange terms to reach

$$\kappa = (1 - \alpha)t^w + \alpha t^r. \tag{14}$$

The aggregate production technology is then given by the standard AK type with constant returns to capital:

$$Y_t = \tilde{A}K_t, \tag{15}$$

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[13]Note that equations (12) and (13) can easily be solved explicitly for s_t and b_{t+1}, which are then functions of individual income I_t, the interest factor R_{t+1}, and next period's net wage $(1 - t^w)w_{t+1}$. Yet, for reasons of convenience and in order to clarify the effect of private intergenerational transfers on savings and growth, I work with the equations mentioned above. This, of course, does not affect any of the results.

where $\tilde{A} = [A((1-\phi)\kappa L_t)^{1-\alpha}]^{1/\alpha}$. Aggregate input prices can thus be rewritten as

$$w_t = (1-\alpha)\tilde{A} K_t L_t^{-1} \tag{16}$$

and

$$r_t = \alpha\tilde{A}. \tag{17}$$

Output and wage rate are proportional to capital and will grow at the same rate as aggregate capital on a balanced growth path. The interest rate and thus also the interest factor R_{t+1} are constant and time-invariant[14]. For a given composition of government expenditures, both marginal productivities increase with the government-spending–output ratio κ, which in turn depends positively on both tax rates. For fixed tax rates instead, input prices also increase if the government changes the composition of expenditures in favour of productive spending (a decrease in the parameter ϕ).

We are now able to define the intertemporal equilibrium of the economy. Given a fiscal policy (parameters t^w, t^r, and ϕ) and an initial value of the capital stock $k_0 = K_0/N_{-1} = s_{-1}$, a perfect-foresight intertemporal equilibrium is characterized by a sequence of quantities and prices:

$$\{c_t,\ d_t,\ k_t,\ s_t,\ b_t;\ w_t,\ r_t\}_{t\geq 0}.$$

Individuals maximize utility, factor markets are competitive, and all markets clear. The market-clearing conditions for the labour, capital and good markets are

$$L_t = N_t, \tag{18}$$

$$K_t = N_{t-1}s_{t-1}, \tag{19}$$

$$Y_t = N_t(c_t + s_t) + N_{t-1}d_t + G_t. \tag{20}$$

For all t, the values of G_t^s and G_t^c are determined by equations (4) and (5). The condition (18) states that the labour market is characterized by full employment;

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[14]The time index will therefore be omitted in the following; it is $R = R_{t+1}$ for all t.

the demand for labour determines the market-clearing wage rate. The condition (19) states that in each period, the stock of capital results from individuals' savings in the preceding period. The demand for capital determines the market-clearing rental rate. According to Walras' law in period t, the equilibrium in the labour and capital market imply that of the good market. Furthermore, we can substitute the young's budget constraint, equation (6) into (20) and make use of (15) and the relation $G_t = \kappa Y_t$ to obtain:

$$(1 - \kappa)\tilde{A}K_t = N_t I_t + N_{t-1}d_t \qquad (21)$$

In a next step, it is shown that the intertemporal equilibrium is characterized by either operative or inoperative bequests, depending on the parents' degree of altruism towards their child. Moreover, the growth rates of the economy in both cases are determined, and the conditions for a balanced growth path are specified. The analysis reveals that there exists an explicit threshold for the altruism parameter λ that indicates which of the two regimes, operative or inoperative bequests, is at work.

The first step is to determine aggregate savings: Summing individual savings, equation (12), over all N_t young individuals and taking the definition of I_t, equation (6), into account gives

$$S_t = \psi(R)[(1 - t^w)w_t N_t + b_t N_t] + (1 - \psi(R))\frac{b_{t+1}N_t}{R}. \qquad (22)$$

Aggregate savings are positively related to aggregate income (the sum of wage income and the amount of bequest received from parents) and to aggregate bequests devoted to children. The impact of an increase in the interest factor is ambiguous, depending on the parameters of the model. In a closed economy, aggregate savings of the young are used to finance next period's capital stock $K_{t+1} = S_t$ (the capital market clearing condition). Therefore, the expression (22) can be used to determine the growth factor of capital, $g_t = K_{t+1}/K_t$. Moreover, by the definition of a balanced growth path, bequests grow at the same rate as capital, i.e., $g_t = b_{t+1}/b_t$. Finally, expressing the wage rate by the marginal productivity of labour, equation (16), yields an implicit expression for

the growth factor of capital,

$$g_t = \psi(R)[(1 - t^w)(1 - \alpha)\tilde{A} + x_t] + (1 - \psi(R))\frac{x_t g_t}{R}, \tag{23}$$

where $x_t = b_t N_t / K_t$ defines the bequest–capital ratio in period t. This ratio equals zero if and only if the economy is bequest-constrained, i.e., $b_t = 0$. Solve (23) for g_t to get an explicit expression for the growth factor:

$$g_t = \tilde{\psi}(R, x_t)[(1 - t^w)(1 - \alpha)\tilde{A} + x_t]. \tag{24}$$

with $\tilde{\psi}(R, x_t) = (R\rho)^\sigma / [R + (R\rho)^\sigma - x_t]$. In the case of inoperative bequests, we have $x_t = 0$. The growth factor is then constant over time, and $\tilde{\psi}(R, 0) = \psi(R)$. In case of operative bequests, however, growth is additionally affected by the bequest–capital ratio x_t. The analysis proceeds by showing that this ratio is constant on a balanced growth path, implying that g_t (in the case of operative bequests) in equation (24) is also constant over time and there are no transitional dynamics.

From the definition of x_t, it follows that $b_t = x_t K_t / N_t$. Dividing equation (13), the optimal amount of bequests devoted by parents to their child, by b_t and recalling that the wage rate grows at the same rate as aggregate capital, i.e., $w_{t+1} = g_t \cdot w_t$, yields

$$\frac{b_{t+1}}{b_t} = \frac{\lambda^\sigma}{1 + \lambda^\sigma} R \frac{s_t N_t}{b_t N_t} - \frac{1}{1 + \lambda^\sigma}(1 - t^w)w_t \frac{g_t}{b_t N_t}.$$

Now, expressing the wage rate in terms of the marginal productivity of labour, equation (16), we get

$$\frac{b_{t+1}}{b_t} = \frac{\lambda^\sigma}{1 + \lambda^\sigma} R \frac{1}{x_t} g_t - \frac{1}{1 + \lambda^\sigma}(1 - t^w)(1 - \alpha)\tilde{A}\frac{1}{x_t}g_t. \tag{25}$$

Further analysis of equation (25) gives rise to the following proposition:

Proposition 1. *On a balanced growth path, the bequest–capital ratio is constant and satisfies*

$$x \equiv x_t = \frac{1}{1 + \lambda^\sigma}\left[\lambda^\sigma R - (1 - t^w)(1 - \alpha)\tilde{A}\right]. \tag{26}$$

Bequests are operative, i.e., $x > 0$, as long as

$$\lambda > \hat{\lambda} = \left(\frac{(1 - t^w)(1 - \alpha)\tilde{A}}{R} \right)^{1/\sigma} . \tag{27}$$

Proof: *Setting $b_{t+1}/b_t = g_t$ in (25) and solving for x_t gives (26). In turn, solving (26) for λ gives the critical value in equation (27).*

The threshold level $\hat{\lambda}$ is related negatively to the wage tax and positively to the capital income tax. Bequests are thus more likely when wage taxes are high, since individuals then foresee that the descendant's economic situation will worsen as net wages will be lower. The inverse relation applies to the capital income tax, because a higher tax rate reduces the old's return to their savings and consequently also the amount of bequest that parents devote to their child. Consequently, excessive capital income taxation may crowd out private intergenerational transfers.

On the basis of these findings, the following subsections will reexamine the effect of capital income taxation with (in)operative bequests on growth for two specific fiscal policies: Firstly, I consider a situation in which the additional revenue from an increase of the capital income tax is used to cut the wage tax and government spending is fixed. This is the fiscal policy examined by Uhlig and Yanagawa (1996), in which the shift of the tax burden generates a pure positive income effect and thus possible positive growth effects due to increased savings. Secondly, an increase of the capital income tax is used to enhance the government-spending–output ratio, thereby boosting output and the marginal productivity of labour as well as capital. Rivas (2003) shows that such a setting constitutes a different source of positive growth effects.

In the following, without loss of generality, population size and thus also labour supply will be normalized to one for reasons of simplicity, i.e. $N_t = L_t = 1$.

2.5. Revenue-neutral tax reform

Throughout this subsection it is assumed that the composition and the level of government expenditures, i.e., the parameters ϕ and κ, are fixed. An increase

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of the capital income tax rate t^r is used to reduce the wage tax t^w, implying that the wage tax is now endogenously determined. Recall the expression for the government-spending–output ratio, equation (14), and solve for t^w to obtain

$$t^w = \frac{\kappa}{1-\alpha} - \frac{\alpha}{1-\alpha} t^r. \tag{28}$$

Under these assumptions, the model is very similar to the one in Uhlig and Yanagawa (1996) if bequests are inoperative. Yet, the engines of growth are different in the two models: In Uhlig and Yanagawa sustained growth results from a positive technological spillover, whereas in this model public services ensure the existence of a balanced growth path. Moreover, the presence of intergenerational transfers in the form of bequests within the family adds additional effects to the growth process. The formal analysis proceeds as follows:

The growth factor in the case of operative bequests, equation (24), depends on the wage tax t^w and the bequest–capital ratio x, where x in turn depends on t^w, equation (26). Plugging equation (28) into both expressions and rearranging terms yields

$$x = R - \frac{\theta}{1 + \lambda^\sigma} \tag{29}$$

and

$$g = \tilde{\psi}(R, x)[\theta - R + x] \tag{30}$$

with $\theta = (1 - \kappa)\tilde{A}$. Now, first look at the case when intergenerational transfers are absent, i.e., $x = 0$. The growth factor is then influenced through two channels that are captured by the two multiplicative factors determining the growth factor in equation (30): Firstly, increasing the capital income tax evokes the well-known opposing substitution and income effects. Therefore, the overall effect on savings and hence on growth is ambiguous and depends on the interest elasticity of savings, which in turn depends on the intertemporal elasticity of substitution[15]. Secondly, raising the capital tax allows for reduction of labour

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[15]The interest factor elasticity of savings is defined as

$$\epsilon(R) = \frac{\partial \psi(R)}{\partial R} \frac{R}{\psi(R)} = \frac{\sigma - 1}{1 + \rho^\sigma R^{\sigma - 1}}.$$

income taxes. This increases the net wage of the working part of the population, thereby leading to more income out of which to save. Thus, the second effect is equivalent to a pure positive income effect and fosters the growth process. The overall effect turns out to be positive if the interest elasticity of savings, denoted $\epsilon(R)$, is sufficiently small—more specifically, if

$$\epsilon(R) < \frac{I_K}{I_L}, \tag{31}$$

where I_K/I_L is the ratio of after-tax capital income to after-tax labour income. This condition is exactly the same as stated by Uhlig and Yanagawa (1996) in their second proposition. The pure positive income effect then outweighs possible negative substitution effects (occurring in the case of $\sigma > 1$).

However, if intergenerational transfers are operative, i.e., $x > 0$, the bequest–capital ratio additionally influences growth via two channels: On the one hand, the presence of intergenerational transfers affects the saving rule.[16] In contrast to the case of $x = 0$, savings are higher, since young individuals not only save for future consumption but also to leave a positive amount of bequest. Yet, an increase of the capital income tax enhances the disposable income of the immediate descendant, as future net wages will increase. Anticipating this positive future income effect, the current young generation reduces its savings in order to transfer a smaller amount of bequest to its children in period $t + 1$.

On the other hand, family members respond to the public income redistribution due to the change in the tax structure by redistributing the total family income (in period t).[17] More specifically, currently old individuals reduce their amount of bequest by exactly the amount that barely offsets the negative income effect due to a declining return to savings and the positive income effect

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[16]Recall that, in contrast to the case of inoperative bequests, this rule is now given by

$$\tilde{\psi}(R, x) = \frac{(R\rho)^\sigma}{R + (R\rho)^\sigma - x}.$$

[17]Note that the tax reform under consideration does not affect total family income in period t, which is the sum of returns to savings from the old plus the net wage of the young, i.e., $\Omega_t = (1 - t^w)w_t + Rs_{t-1}$. It is straightforward to show that $\partial\Omega_t/\partial t^r = 0$.

of the young individuals resulting from an increasing net wage.

Analytically, this can be shown by inserting equation (29) into (30). One then obtains a simple expression for the growth factor with operative bequests that solely depends on the interest factor R:

$$g = \frac{(R\rho)^\sigma}{(R\rho)^\sigma + \frac{\theta}{1+\lambda^\sigma}} \left[\frac{\lambda^\sigma}{1+\lambda^\sigma}\theta\right]. \tag{32}$$

From this equation, it is easy to see that the positive income effect is exactly canceled out by an appropriate decrease of the bequest–capital ratio, since θ is independent of the capital income tax rate. Moreover, optimal individual savings always decline due to an increase of the capital income tax, as argued above.

To summarize, I have shown the following:

Proposition 2. *A revenue-neutral increase of the capital income tax that decreases the wage tax*

1. *may increase growth in the case of inoperative bequests if the interest elasticity of savings is sufficiently small, i.e.,*

$$\epsilon(R) < \frac{I_K}{I_L};$$

2. *unambiguously decreases growth if bequests are operative.*

Proof: *In the case of inoperative bequests, we have $x = 0$. Taking the derivative of equation (30) with respect to t^r gives*

$$\frac{\partial\psi(R)}{\partial R}(\theta - R) - \psi(R) < 0.$$

Rewriting this inequality yields the result.

The saving rule in the case of operative bequests is

$$\tilde{\psi}(R, x) = \frac{(R\rho)^\sigma}{R + (R\rho)^\sigma - x}.$$

Insert the bequest–capital ratio x, equation (29), to reach

$$\tilde{\psi}(R) = \frac{(R\rho)^\sigma}{(R\rho)^\sigma + \frac{\theta}{1+\lambda^\sigma}} > 0.$$

Taking the derivative with respect to the capital income tax rate t^r gives

$$\frac{d\tilde{\psi}(R)}{dt^r} = -\frac{\theta}{1+\lambda^\sigma}\tilde{\psi}(R) < 0.$$

It follows that an increase of t^r always reduces growth.

The analysis reveals that the overall effect is always negative. Consequently, the introduction of intergenerational transfers within the family constitutes an additional objection to the results found by Uhlig and Yanagawa (1996). In their paper, they already admit that there are no positive growth effects if the overlapping-generations structure is extended to multiple periods of life. The same holds if parents are concerned about the disposable income of their child.

2.6. Increasing public services

Now, consider a situation in which the composition of government expenditures, ϕ, and the labour tax rate, t^w, are fixed. An increase of the capital income tax rate is used to enhance productive government spending, implying that the government-spending–output ratio κ is now endogenous and equation (14) holds.

Under these assumptions the model is very similar to the one in Rivas (2003) in the case of inoperative bequests. However, if bequests are operative, there is an additional channel that influences growth as in the preceding section. In contrast to the model in Uhlig and Yanagawa (1996), where the government finances a fixed level of government consumption, the government is now provided with an active role in the economy by allocating tax revenues to different categories of spending. Moreover, growth is now primarily driven by changes in productivity rather than by shifts of the tax burden.

In order to assess the effect of capital income taxation on long-run growth, it turns out to be important to determine the effect on the long-run interest rate. Following Rivas (2003), I first analyze the impact of an increase in the capital income tax on the interest factor R, and then determine the effect on growth. Taking the definition of the productivity index $\tilde{A}$ into account, the

interest factor becomes

$$R = (1 - t^r)\alpha A^{1/\alpha}[(1 - \phi)\kappa]^{(1-\alpha)/\alpha}. \tag{33}$$

It is easy to see that R is decreasing in ϕ and increasing in t^w. However, there exists a nonlinearity with respect to t^r, since an increase of the capital income tax decreases the capital tax factor on the one hand but enhances the government-spending–output ratio κ (i.e., $\partial\kappa/\partial t^r = \alpha > 0$) on the other hand. The overall effect can be written as

$$\frac{\partial R}{\partial t^r} = R(\vartheta(t^r) - \varphi(t^r)) \tag{34}$$

with

$$\vartheta = \frac{\partial\tilde{A}/\partial t^r}{\tilde{A}} = \left(t^w + \frac{\alpha}{1-\alpha}t^r\right)^{-1}$$

and

$$\varphi = (1 - t^r)^{-1}.$$

Here ϑ is the rate of change in total factor productivity due to changes in capital taxation, and φ the rate of change in the capital tax factor, which can be interpreted as the degree of distortion due to capital income taxation. Depending on the relative strength of the two effects, an increase of the capital income tax may either increase or decrease the net-of-tax interest rate, which in turn depends on the existing level of taxation. These results are summarized in the next proposition:

Proposition 3. *The interest factor R is a concave function of the capital income tax t^r, reaching a maximum at $\bar{t}^r = (1 - \alpha)(1 - t^w)$. The direction of the change in the interest rate (for given labour tax and expenditure composition) due to an increase of the capital income tax depends on the ratio of government revenue from capital taxation to the net-of-tax capital income of the private sector (equal to R) for a given tax rate. It is given by*

$$\frac{\partial R}{\partial t^r} \gtrless 0 \quad \Leftrightarrow \quad \hat{A}_{t^r} \gtrless \frac{M_K}{R},$$

where

$$\hat{A}_{t^r} = \vartheta t^r = \frac{\partial \tilde{A}}{\partial t^r} \frac{t^r}{\tilde{A}} = \left(\frac{t^w}{t^r} + \frac{\alpha}{1-\alpha} \right)^{-1}$$

is the elasticity of productivity with respect to the capital tax rate, and $M_K = t^r \alpha \tilde{A}$ is the government's per unit of capital revenue from capital income taxation.

Proof: *Consider the function*

$$B(t^r) = \vartheta(t^r) - \varphi(t^r).$$

It is then straightforward to check that $B(\bar{t}^r) = 0$, where $0 < \bar{t}^r = (1-\alpha)(1 - t^w) < 1$. Moreover, rewriting the inequality $t^r B(t^r) \gtrless 0$ yields the equivalence stated above. In order to establish concavity, note that $\varphi(0) = 1 < 1/t^w = \vartheta(0)$ with $\varphi'(t^r) > 0$ and $\vartheta'(t^r) < 0$ for $t^r \in [0,1)$. Consequently, ϑ and φ intersect only once in the relevant range, namely at $\hat{t}^r$.

Note that these results are essentially the same as in Rivas (2003). What differs, however, is the restrictions imposed on the tax rate parameters. In this model the only restriction is $t^r < 1$ in order to have a positive net-of-tax interest factor. Rivas, by contrast, imposes an upper (lower) bound on the capital (labour) income tax rate to ensure sustained growth. Those differences result from the simplifying assumption of complete capital depreciation on the one hand and the fact that lifetime income may be positive even if labour income is completely taxed away due to intergenerational transfers on the other hand.

We are now in a position to analyze the overall effect of an increase in the capital income tax rate on growth in the case of (in)operative bequests. Recall therefore equation (24), the growth factor. Similarly to the preceding section, growth is affected through three channels with respect to capital income taxation: Firstly, an increase in the capital income tax enhances productivity and thus wages and income. Secondly, changes in capital taxation affect the real rate of return, which in turn affects growth. The direction of this latter effect depends on the interest elasticity of savings. Finally, the presence of intergenerational transfers distorts the individual saving rule on the one hand

and induces an adjustment of private intergenerational transfers on the other hand. In order to simplify the theoretical analysis, insert the bequest–capital ratio x, equation (26), into the growth factor, equation (24), and collect terms to reach

$$g = \frac{(R\rho)^\sigma}{(R\rho)^\sigma + \frac{1}{\lambda^\sigma}I(R,\tilde{A})} \cdot I(R,\tilde{A}) \tag{35}$$

with

$$I(R,\tilde{A}) = \frac{\lambda^\sigma}{1+\lambda^\sigma}[R + \bar{t}^r\tilde{A}].$$

Depending on the existing level of capital taxation, the model features positive growth effects even if bequests are operative:

Proposition 4. *Suppose that the the rate of capital income taxation is sufficiently low, i.e., $t^r < \bar{t}^r$, and that the composition of government spending is fixed. Increasing the capital income tax then enhances growth even if bequests are operative.*

Proof: *In the following, the elasticity of a variable k with respect to the argument j will be denoted $\hat{k}_j$.*

The elasticity of the growth factor with respect to t^r is then

$$\hat{g}_{t^r} = \hat{g}_R\left(\hat{\tilde{A}}_{t^r} - \frac{M_K}{R}\right)g + \hat{g}_I\hat{I}_{t^r}.$$

Calculating and inserting the respective elasticities, this equation can be rewritten as

$$\hat{g}_{t^r} = g\left[\frac{\sigma}{\lambda^\sigma(R\rho)^\sigma}\left(\hat{\tilde{A}}_{t^r} - \frac{M_K}{R}\right) + \frac{(1-\alpha-\kappa)t^r\tilde{A}}{\frac{1+\lambda^\sigma}{\lambda^\sigma}\kappa I}\right]. \tag{36}$$

Taking the definition of κ into account, it is straightforward to show that the second term in the brackets is positive if and only if the initial capital income tax rate is not too high, i.e., if $t^r < \bar{t}^r/\alpha$. In this case, the positive income effect of higher net wages always offsets the (possibly) negative effect on individual income due to a reduced amount of bequest. Consequently, for $t^r < \bar{t}^r$ one has $\hat{\tilde{A}}_{t^r} > M_K/R$, and the above expression is clearly positive.

Two remarks are in order. First, note that the inequality stated in the above proposition is a sufficient condition but not necessary. From equation (36) it

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is easy to see that positive growth results are still possible even if the existing capital income tax level exceeds the threshold value $\bar{t}^r$. In fact, there exists a growth-maximizing level of the tax rate as long as $\bar{t}^r < t^r < \bar{t}^r/\alpha$. Second, if intergenerational transfers are absent, i.e., $x = 0$, the model is equivalent to the one in Rivas (2003). The growth factor, equation (24), can then be written as

$$g = \tilde{\psi}(R,0) \cdot \frac{1 + \lambda^\sigma}{\lambda^\sigma} I(0, \tilde{A}) = \frac{(R\rho)^\sigma}{(R\rho)^\sigma + R} \bar{t}^r \tilde{A}, \tag{37}$$

implying that

$$\hat{g}_{t^r} = \epsilon(R) \left(\hat{\tilde{A}}_{t^r} - \frac{M_K}{R} \right) + \hat{\tilde{A}}_{t^r}. \tag{38}$$

A positive growth effect in this case requires not only a sufficiently small prevalent capital income tax rate as above, i.e., $t^r < \bar{t}^r$, but also an interest elasticity of savings, $\epsilon(R)$, that exceeds zero. More specifically, the substitution effect must dominate the income effect, which is fulfilled if $\sigma \geq 1$. Consequently, a positive growth result can be obtained under weaker assumptions when individuals have the possibility to redistribute income within the family.

So what is the intuition behind these results? An increase of the capital income tax increases the flow of public services if the composition of spending is unaltered. This in turn enhances total factor productivity, thereby increasing the real wages and thus the individual income of the young. Consequently, individuals are left with more income out of which to save. This is the direct effect of capital taxation, which increases aggregate savings and growth. Furthermore, income is affected by the amount of bequest that individuals receive from their parents. This amount may either increase or decrease, depending on the relative strength of the effects from increased capital taxation on the wage and on the interest rate: If the positive income effect of the young offsets the (ambiguous) effect stemming from changes in the rate of return to the old's savings, the amount of bequest declines as parents deal with the negative effect of public income redistribution on their own income by adjusting private intergenerational transfers.[18]

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[18] Analytically, it is straightforward to show that a sufficient condition for bequests to de-

There are two more indirect effects at work: On the one hand, movements of the capital tax rate affect the after-tax rate of return to savings and thus the intertemporal price of consumption. The direction of this effect depends on the direction of change in the interest rate and on how individuals adapt their consumption–saving decision to this change. On the other hand, the presence of intergenerational transfers affects the individual saving decision even further, since individuals adapt the amount of bequest devoted to their child, and thus their savings, to changes in the capital income tax rate. If future net wages increase, the current young individuals save less to give a smaller amount of bequest to their descendants. Yet, the effect of increased capital taxation on the individual saving decision is clear: savings decline if and only if future income increases and the interest rate decreases.

To sum up, the overall effect on growth is generally ambiguous. However, the analysis does not exclude positive growth effects even if bequests are operative.

So far, the analysis has shed light on the question how capital income taxation affects growth under two specific fiscal policies when intergenerational transfers are operative. The following subsection, by contrast, examines the impact of the outlay of government expenditures on growth.

2.7. Changing the expenditure composition

In this subsection it is assumed that the tax rates, t^w and t^r, and thus also the total share of government expenditures, κ, are fixed. The focus is now on changes in the parameter ϕ—more specifically, a situation in which the government decides to reduce the amount of spending on public services in favour of an increase in government consumption, i.e., an increase in ϕ. In the related model where intergenerational transfers are absent, Rivas (2003) shows that such a policy unambiguously decreases growth if the interest elasticity of savings exceeds zero. The intuition behind this result is that a decline in

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cline, i.e., $\partial(1 - t^w)w_t/\partial t^r > \partial Rs_{t-1}/\partial t^r$, is $\alpha \geq 0.5$. In this case, the effect of capital taxation on individual income is ambiguous, depending on the trade-off between higher net wages and reduced bequests.

government services reduces productivity and consequently the return on savings and real wages. If the interest elasticity is sufficiently large, both channels will reduce savings and thus growth. However, the situation is not that clear if intergenerational transfers are operative. The overall effect on growth then additionally depends on how private income redistribution within the family reacts to such a policy reform.

In analogy to the preceding section, the amount of bequest that parents devote to their child decreases if the negative income effect on the young caused by declining real wages is larger than the negative income effect on the old that stems from a decreased rate of return to savings.[19] Consequently, bequests and thus also individual and aggregate income may well increase through this channel. The overall effect on income is then characterized by a trade-off between lower real wages and a larger amount of bequests. Yet, analytical results indicate that the negative effect always offsets the (possibly) positive effect. Furthermore, individual savings decline as interest rates decrease and also as individuals have less income out of which to save due to the negative income effect. These results are summarized in the following proposition:

Proposition 5. *A larger share of total government outlays allocated to government consumption unambiguously decreases growth.*

Proof: *Recall the growth factor, equation (35). The elasticity of growth with respect to the parameter ϕ can then be written as*

$$\hat{g}_\phi = \hat{g}_R \hat{R}_\phi + \hat{g}_I \hat{I}_\phi$$

with

$$\hat{g}_R = \frac{\lambda^\sigma (R\rho)^\sigma}{\sigma} g > 0, \quad \hat{g}_I = \frac{g}{I} > 0, \quad \hat{I}_\phi = \frac{(1-\kappa)\tilde{A}}{\frac{1+\lambda^\sigma}{\lambda^\sigma} I} \hat{\tilde{A}}_\phi < 0,$$

$$\hat{R}_\phi = \hat{\tilde{A}}_\phi < 0, \quad and \quad \hat{\tilde{A}}_\phi = -\frac{(1-\alpha)\phi}{\alpha(1-\phi)} < 0.$$

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[19] Analytically, it can be shown that bequests decline if the initial capital income tax rate is sufficiently small, i.e., $\partial(1-t^w)w_t/\partial t^r > \partial R s_{t-1}/\partial t^r \Leftrightarrow t^r < 1 - \bar{t}^r/\alpha$. Yet, total family income always declines due to the policy reform under consideration.

Consequently, the overall effect is clearly negative.

The intuition behind this result is simple: Private income redistribution is not capable of offsetting the negative income effects through declining real wages and lower rates of return to savings. This is due to the fact that every generation is hit in the same negative way by such a policy reform. In contrast to the results found by Rivas (2003), we do not have any restrictions on the intertemporal substitution elasticity; this means that private income redistribution contributes an additional negative effect to the analysis, thereby ruling out possible positive effects.

2.8. Simulations

Since in general some of the above results have ambiguous effects on growth, this subsection conducts a numerical calibration exercise using US data in order to illustrate how the different tax policies from the preceding sections may affect growth.

Before computing these growth effects, the parameters of the model have to be fixed. Note that one period in the model is assumed to last half a generation, i.e., 30 years. Following Uhlig and Yanagawa (1996), the capital income share α is fixed at 0.4. Furthermore, the parameter $\tilde{A} = Y/K$ is set to 12, corresponding to a capital–output ratio of 10.59 on a quarterly basis. A is then chosen to match $Y/K = 12$.

The choices of the capital and labour income tax rates are taken from Rivas (2003) and set to 35% and 40% respectively. The first value is drawn from IRS data, while the second one is chosen to match the average share of US total outlays of GDP over the period 1960–1995, amounting to 38%. The corresponding average share of government consumption expenditures of GDP is 17.4% for the same time period.[20] Accordingly, the spending composition parameter is set so that $\phi = 0.6$.[21] On the side of the households, the altruism parame-

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[20]See OECD Historical Statistics 1995.

[21]Note that we do not consider expenditures on government transfers. Consequently, the value for the composition parameter is higher than the one implied by the data, i.e., $\phi = 0.53$, for the same time horizon as mentioned above.

ter λ is adjusted to generate a steady-state bequest–capital ratio of 43% for a given value of the intertemporal substitution elasticity (DeLong, 2003, Fig. 2-1). Further, the individual discount rate δ is chosen to match annual growth and after-tax interest rates of 2% and 4.8% (for given σ). With respect to the value of the intertemporal elasticity of substitution in consumption, there exists no consensus in the econometric literature. Consequently, most studies, like Uhlig and Yanagawa (1996) or Dalgaard and Jensen (2007), assume log utilities, i.e., $\sigma = 1$.[22] Since the intertemporal elasticity of substitution in consumption is crucial in determining the reaction of individual savings, alternative scenarios with $\sigma = 5/6$ and $\sigma = 10/7$ are also included in the analysis.[23] The parameters of the model are summarized in table 1.

[Insert table 1 here.]

Tables 2 and 3 summarize the results when an increase in capital income taxation is used either to cut wage taxes or to enhance public services, respectively, while table 4 lists the results of changes in government's spending composition in favour of government consumption. In each table the effects of the respective policy reform on the bequest–capital ratio x, the (annual) interest factor R, and, for varying σ, the (annual) growth factor g, as well as its derivative with respect to either the capital income tax ($\partial g/\partial t^r$) or the spending composition parameter ($\partial g/\partial \phi$), are displayed. The first column of each table shows the benchmark case.

[Insert table 2 here.]

First, look at table 2. A 5-percentage-point increase of the capital income tax allows for a reduction of the wage tax by 3%, while such an increase leads to a decline of the annual interest rate by approximately 0.2%. As long as bequests are operative, i.e., $x > 0$, growth unambiguously decreases. For example, in the

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[22]Dalgaard and Jensen (2007) justify this, observing that the empirical savings elasticity is more or less constant. This implies that substitution and income effects offset each other, which will only be the case if $\sigma = 1$.

[23]These choices again correspond to the values used by Rivas (2003), who carries out a similar calibration exercise.

case of $\sigma = 1$, a 5-percentage-point increase in the capital income tax from 35% to 40% reduces the annual growth rate by 0.13%. Yet, if bequests are no longer operative, i.e., $x = 0$, the growth effects are reversed, and a further increase in the capital income tax then enhances growth as in Uhlig and Yanagawa (1996).

[Insert table 3 here.]

Second, look at table 3. Raising the capital income tax rate by 5 percentage points in this case allows one to increase the share of total government spending in the GDP by 2%. The annual interest factor declines, and the decline becomes more pronounced the higher the existing level of capital income taxation.[24] By contrast, incremental increases of the capital income tax by 5% enhance growth whether bequests are inoperative *or* operative. Note, however, that if $x > 0$ the growth effects are very small and there seems to exist a growth-maximizing tax rate, which is, for example, between 40% and 45% for $\sigma = 1.43$.

[Insert table 4 here.]

Finally, look at table 4. Raising the share of public spending in government consumption in favour of public services unambiguously and severely decreases annual growth and interest rates as factor productivity declines. For example, enhancing ϕ from 60% to 65% reduces the annual interest rate by 0.51% and the annual growth rate (in the case $\sigma = 1$) by 0.54%. Yet, a 5-percentage-point increase in ϕ enhances the bequest–capital ratio by 2%[25], indicating that the negative income effect of the young generation is more severe than the decline in the old's return to savings.

What are the policy conclusions to be drawn from this calibration exercise? Of course, the model cannot exactly mirror the situation in the US. Still, it points to some important insights concerning the relation of capital

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[24]Note, however, that for the chosen parameters values, the critical capital tax rate $\bar{t}^r$ amounts to 36%, implying that, in the benchmark case, a slight increase in t^r actually increases the interest factor.

[25]For the chosen parameter values, bequests would decrease as a reaction to the policy reform under consideration if $t^r < 0.1$.

income taxation and growth: First, the intergenerational transfers within the family do affect this relation and may even reverse positive results found by previous studies. Second, the reallocation of additional revenue from capital income taxation matters in determining the sign of the growth effect. From a growth-maximizing point of view, the analysis suggests enhancing productive government spending (e.g., investment in infrastructure) rather than lowering wage taxes. Third, shifts in the composition of total government outlays towards unproductive spending may severely affect growth.

3. Extension: Welfare Effects

So far, the analysis has focused on the growth effects of increasing capital taxation and a shift in the spending composition towards government consumption. However, it remains unclear in which way these policy reforms affect the welfare of the living generations, the currently young which is able to fully adjust private decision making to fiscal policy and the presently old generation that has decided on the amount of savings, s_{t-1}, prior to any policy changes. Yet, this is of special importance in determining the political support for any reform. To address this issue, the following section sheds light on the questions whether a reform capable of generating a positive growth effect additionally leads to a welfare gain for the economy and if such a gain is still possible for a negative growth effect. To this end, the welfare effects of the policy reforms today are evaluated for the currently young and old generation thereby distinguishing the cases of operative and inoperative bequests.

In order to simplify the analysis, we restrict ourself to the case of log-utilities, i.e. $\sigma = 1$, noting that this is in line with most of the empirical literature. The utility function (9) then takes the simple form

$$U_t(c_t, d_{t+1}, I_{t+1}) = \ln c_t + \rho[\ln d_{t+1} + \lambda \ln I_{t+1}]. \tag{39}$$

and the growth factors with operative and inoperative bequests, equations (30) and (35), simplify to

$$g_t = \frac{\rho}{1 + \rho}(1 - t^w)(1 - \alpha)\tilde{A} \tag{40}$$

30

and

$$g_t = \frac{R\rho}{R\rho + \frac{\theta}{1+\lambda}} \frac{\lambda}{1+\lambda} \theta, \tag{41}$$

respectively, with $\theta = (1 - \kappa)\tilde{A}$.

Inoperative bequests

We first consider the welfare effects when the economy is bequest constrained, i.e. $b_{t+1} = 0$ in period $t + 1$. To derive the individual's indirect utility function, henceforth denoted by V_t, we have to determine consumption, c_t and d_{t+1}, and next period's income, I_{t+1}. By combining equations (8), next period's income in case of inoperative bequests, and (21), the good market equilibrium condition, we obtain:

$$I_{t+1} = (1 - t^w)(1 - \alpha)\tilde{A}K_{t+1} \tag{42}$$

$$d_{t+1} = RK_{t+1}. \tag{43}$$

Using the first order condition of individual utility maximization, equation (10), we then get a simple expression for first period consumption:

$$c_t = \frac{1}{\rho}K_{t+1}. \tag{44}$$

By inserting (42), (43) and (44) into (39) and simplifying terms, we can then write the individual's indirect utility function as

$$V_t = (1 + \rho(1 + \lambda)) \ln g_t + \ln R + \rho\lambda \ln[(1 - t^w)(1 - \alpha)\tilde{A}] + M_t \tag{45}$$

where M_t is a constant that does not depend on any policy or individual decision variables. Clearly, the welfare of a young individual of generation t is affected through various channels: First, it depends on how growth is influenced by the different policy reforms as analyzed in the preceding sections. Higher growth rates unambiguously enhance welfare as output and thus also individual income, which in turn determines consumption levels, increase. Second, the welfare of generation t is sensitive to changes in the (after tax) interest factor. A higher return to savings clearly increases consumption possibilities as this, other things being equal, has a positive impact on individual's second period income which

is completely used for consumption when bequests are inoperative. Finally, the policy reforms directly affect future income which in turn has a positive impact on individual's welfare level due to the specification of the utility function and the bequest motive.

We are now in position to evaluate the welfare effects for the currently young generation with respect to the different policy reforms. To do so, we differentiate (45) with respect to t^r and ϕ. In case of a revenue neutral tax shift, i.e. the wage tax is endogenously determined and equation (28) holds, we have:

$$\frac{\partial V_t}{\partial t^r} = \frac{1 + \rho(1 + \lambda)}{g_t} \frac{\partial g_t}{\partial t^r} + \frac{1}{R} \frac{\partial R}{\partial t^r} - \frac{\rho \lambda}{1 - t^w} \frac{\partial t^w}{\partial t^r} > 0 \tag{46}$$

as $\frac{\partial t^w}{\partial t^r} = -\frac{\alpha}{1-\alpha} < 0$, $\frac{\partial g_t}{\partial t^r} = \frac{\rho}{1+\rho}(1 - \alpha)\tilde{A}\frac{\partial(1-t^w)}{\partial t^r} > 0$ and $\frac{\partial R}{\partial t^r} = -\alpha\tilde{A} < 0$. Consequently, there is a welfare gain for the currently young generation.

When combined with an expansion in government spending, i.e. κ is now endogenous and (14) holds, an increase in the capital income tax yields the following comparative static result:

$$\frac{\partial V_t}{\partial t^r} = \frac{1 + \rho(1 + \lambda)}{g_t} \frac{\partial g_t}{\partial t^r} + \frac{1}{R} \frac{\partial R}{\partial t^r} + \frac{\rho \lambda}{\tilde{A}} \frac{\partial \tilde{A}}{\partial t^r} \tag{47}$$

with $\frac{\partial \tilde{A}}{\partial t^r} = \frac{1-\alpha}{\kappa}\tilde{A} > 0$, $\frac{\partial g_t}{\partial t^r} = \frac{\rho}{1+\rho}\bar{t}^r\frac{\partial \tilde{A}}{\partial t^r} > 0$ and $\frac{\partial R}{\partial t^r} \gtrless 0 \Leftrightarrow t^r \lessgtr \bar{t}^r$. The welfare effect is thus unambiguously positive if $t^r < \bar{t}^r$ which is, however, a by far sufficient condition.

Finally, differentiating V_t with respect to ϕ gives

$$\frac{\partial V_t}{\partial \phi} = \frac{1 + \rho(1 + \lambda)}{g_t} \frac{\partial g_t}{\partial \phi} + \frac{1}{R} \frac{\partial R}{\partial \phi} + \frac{\rho \lambda}{\tilde{A}} \frac{\partial \tilde{A}}{\partial \phi} < 0 \tag{48}$$

as $\frac{\partial \tilde{A}}{\partial \phi} = -\frac{1-\alpha}{\alpha(1-\phi)}\tilde{A} < 0$, $\frac{\partial g_t}{\partial \phi} = \frac{\rho}{1+\rho}\bar{t}^r\frac{\partial \tilde{A}}{\partial \phi} < 0$ and $\frac{\partial R}{\partial \phi} = (1 - t^r)\alpha\frac{\partial \tilde{A}}{\partial \phi} < 0$. Changing the composition of government expenditures in favor of government consumption therefore clearly reduces welfare for the currently young generation.

By contrast, the welfare effects for the currently old population are obtained by considering the impact of the policy reforms on d_t and I_t as these individuals can no longer adjust to changes in the policy parameters. Rather, decisions on

the amount of savings of this generation, s_{t-1}, have been made prior to the policy reforms. Formally we thus have to analyze the following utility function:

$$U(c_{t-1}, d_t, I_t) = \ln c_{t-1} + \rho[\ln d_t + \lambda \ln I_t] \tag{49}$$

where c_{t-1} is constant and denotes consumption of a young individual born in $t-1$. Inserting (43) and (42) for period t into (49) and simplifying terms yields:

$$V_t^{old} = \ln R + \lambda \ln((1 - t^w)(1 - \alpha)\tilde{A}) + \bar{M}_t \tag{50}$$

Clearly, a revenue neutral tax reform affects the old's welfare in an ambiguous way: On the one hand it reduces the after tax interest factor, thereby lowering the return to savings and thus old-age consumption. On the other hand, however, a decreasing wage tax enhances the disposable income of the immediate descendant which has a welfare-enhancing effect. As will be shown below, the positive effect dominates for a sufficiently low level of the capital income tax. Regarding the expansion of government expenditures, financed by capital income taxation, such a policy will unambiguously increase the old's welfare as long as the interest rate increases which holds for $t^r < \bar{t}^r$ according to proposition 3. In this case, both old age consumption and the disposable income of the children will be higher implying a welfare gain for the presently old generation. Finally, shifting government expenditures from productive resources to unproductive government consumption clearly reduces welfare for the old as productivity and consequently also income consumption possibilities decline.

The above results are summarized in the following proposition:

Proposition 6. *Suppose that parent's degree of altruism is sufficiently low, i.e.* $\lambda < \hat{\lambda}$. *Then bequests are inoperative and a revenue neutral increase of the capital income tax that decreases the wage tax*

- *enhances welfare for the currently young generation.*

- *enhances welfare for the presently old generation if the existing level of capital income taxation is not too high, i.e.* $t^r < 1 - \frac{1-\kappa}{(1+\lambda)\alpha}$

33

When combined with an expansion in government spending, an increase in the capital income tax

- *enhances welfare for the presently old and the currently young generation if the prevalent tax level is sufficiently small, i.e. $t^r < \bar{t}^r$.*

A shift in government expenditures towards government consumption unambiguously reduces welfare for all present generations.

Proof: *According to proposition 1, bequests are inoperative, as long as $\lambda < \hat{\lambda}$. The condition for a welfare gain of the presently old generation under the revenue neutral tax reform can be shown as follows: Taking the derivative of (49) with respect to t^r gives:*

$$\frac{\partial V_t^{old}}{\partial t^r} = -\frac{1}{1-t^r} + \frac{\lambda\alpha}{(1-t^w)(1-\alpha)} \tag{51}$$

Inserting the wage tax (28) and rearranging terms, (51) will be positive if and only if $t^r < 1 - \frac{1-\kappa}{(1+\lambda)\alpha}$.

Consequently, when bequests are inoperative, a revenue neutral tax reform in favor of capital income taxation may not only increase growth but also enhance welfare for all present generations if the level of capital income taxation is relatively low. A similar result obtains if the increase in the capital income tax is combined with an expansion in public expenditures: For sufficiently low levels of capital income taxation, such a policy reform will have a growth- and welfare-enhancing effect, while a shift of government expenditures from productive resources to unproductive government consumption will not only harm growth but also reduce welfare for all present generations.

Operative bequests

In a next step, we turn to the case when bequests are operative, i.e. $b_{t+1} > 0$ in $t+1$. By combining (10), (11) and (21),next period's income, old-age and first period consumption can be written as

$$I_{t+1} = \frac{\lambda}{1+\lambda}\theta K_{t+1} \tag{52}$$

$$d_{t+1} = \frac{1}{1+\lambda}\theta K_{t+1} \tag{53}$$

$$c_t = \frac{1}{(1+\lambda)\rho R}\theta K_{t+1}. \tag{54}$$

Insert these expressions into (39) and simplify terms, to obtain the individual's indirect utility function

$$V_t = (1 + \rho(1+\lambda))\ln g_t - \ln R + (1 + \rho(1+\lambda))\ln\theta + \tilde{M}_t \tag{55}$$

where $\tilde{M}_t$ is again a constant that does not depend on any policy or individual decision variables. In analogy to the case of inoperative bequests, the welfare of a young individual of generation t is sensitive to changes in the growth and interest rate: Both channels increase future consumption possibilities and thus welfare. Furthermore, welfare is positively affected through increases in productivity which in turn raises income and consequently consumption levels.

Evaluating the individual's indirect utility function with respect to the different policy reforms, starting with the revenue neutral tax shift, we obtain:

$$\frac{\partial V_t}{\partial t^r} = \frac{1 + \rho(1+\lambda)}{g_t}\frac{\partial g_t}{\partial t^r} - \frac{1}{R}\frac{\partial R}{\partial t^r} \tag{56}$$

with $\frac{\partial g_t}{\partial t^r} = -\frac{1+\rho(1+\lambda)}{1+\lambda}\theta < 0$ according to proposition 2 and $\frac{\partial R}{\partial t^r} = -\alpha\tilde{A} < 0$. The welfare effect for the young generation is thus generally ambiguous, depending on the relative strength the policy reform exerts on the growth and interest factor. Yet, as will be shown below, a welfare gain obtains for sufficiently large levels of capital income taxation.

When the increase in the capital tax is instead combined with an expansion in government expenditures, i.e. (14) holds, the derivative becomes

$$\frac{\partial V_t}{\partial t^r} = \frac{1 + \rho(1+\lambda)}{g_t}\frac{\partial g_t}{\partial t^r} - \frac{1}{R}\frac{\partial R}{\partial t^r} + \frac{1 + \rho(1+\lambda)}{\theta}\frac{\partial \theta}{\partial t^r} \tag{57}$$

with $\frac{\partial g_t}{\partial t^r} > 0$ if $t^r < \bar{t}^r$ as can be inferred from (36) (for $\sigma = 1$), $\frac{\partial R}{\partial t^r} \gtrless 0 \Leftrightarrow t^r \lessgtr 0$ (proposition 3) and $\frac{\partial \theta}{\partial t^r} = \frac{1-\alpha-\kappa}{\kappa}\tilde{A} \gtrless 0 \Leftrightarrow t^r \lessgtr \bar{t}^r/\alpha$ where κ is determined by (14). Consequently, the sign of the welfare effect is determined by the relative strength of three (partly) opposing effects: The growth effect, the impact of the interest factor on the individual consumption/saving decision as well as the

effect of the policy reform on individual income and the amount of bequest, as captured by θ.

Finally, shifting government expenditures towards government consumption, we get:

$$\frac{\partial V_t}{\partial \phi} = \frac{1 + \rho(1 + \lambda)}{g_t}\frac{\partial g_t}{\partial \phi} - \frac{1}{R}\frac{\partial R}{\partial \phi} + \frac{1 + \rho(1 + \lambda)}{\theta}\frac{\partial \theta}{\partial \phi} \tag{58}$$

with $\frac{\partial g_t}{\partial \phi} < 0$ (proposition 5), $\frac{\partial R}{\partial \phi} = (1 - t^r)\alpha\frac{\partial \tilde{A}}{\partial \phi} < 0$ and $\frac{\partial \theta}{\partial \phi} = (1 - \kappa)\frac{\partial \tilde{A}}{\partial \phi} < 0$, implying that the welfare effect for the currently young generation is unambiguously negative.

In analogy to the case of inoperative bequests, we now analyze the welfare effects for the currently old generation. To obtain the indirect utility function of an individual born in $t - 1$, insert (53) and (52) (for period t) into the old's utility function (49) and simplify terms to reach:

$$V_t^{old} = \rho(1 + \lambda)\theta + \hat{M}_t. \tag{59}$$

It is easy to see that a revenue neutral tax reform does not affect the old's welfare as these individuals encounter any change in their old age consumption level by adjusting private intergenerational transfers. Consequently, the amount of bequest decreases as future income increase and old-age consumption declines. The effect of an expansion in public expenditures, however, enhances the old's welfare for sufficiently low levels of capital income taxation, i.e. $t^r < \bar{t}^r/\alpha$. Then, the positive income effect of higher (net) wages offsets the (possibly) negative effect on individual income due to a reduced amount of bequest and θ increases. Clearly, as compared to the case when bequests are inoperative, an increase in ϕ unambiguously reduces welfare for the old as productivity and thus income and consumption levels decline.

The welfare implications for operative bequests are summarized in the following proposition:

Proposition 7. *Suppose that parent's are sufficiently altruistic towards heir children, i.e. $\lambda > \hat{\lambda}$. Then bequests are operative and a revenue neutral increase of the capital income tax that decreases the wage tax*

1. *may enhance welfare of the currently young generation if the prevalent level of capital income taxation is sufficiently high, i.e. $t^r > 1 - \frac{1+\lambda}{(1+\rho(1+\lambda))\theta}$.*

2. *does not affect welfare for the presently old generation.*

When combined with an expansion in government spending, an increase in the capital income tax

1. *has an ambiguous effect on the welfare of the currently young generation.*

2. *enhances welfare for the presently old generation, if the existing level of capital taxation is sufficiently low, i.e. $t^r < \bar{t}^r/\alpha$.*

A shift in government expenditures towards government consumption unambiguously reduces welfare for all present generations.

Proof: *According to proposition 1, bequests are operative, as long as $\lambda < \hat{\lambda}$. The welfare gain for the currently young generation under the revenue neutral tax reform can be shown as follows: Inserting the derivatives of the growth and interest factor into $\frac{\partial V_t}{\partial t^r} > 0$ and rearranging terms yields:*

$$\frac{\alpha \tilde{A}}{(1 - t^r)\alpha \tilde{A}} > \frac{1 + \rho(1 + \lambda)}{1 + \lambda}\theta. \tag{60}$$

Solving this inequality for t^r then proves the argument.

When bequests are operative, the welfare effects are no longer as clear cut as in the case of inoperative bequests and generally depend on the relative strength of how the reform affects the growth and interest factor. Still, for the revenue neutral tax reform, there might be a welfare gain for the currently young generation despite a negative growth effect. Thus, political support might not be lacking even in case of declining growth rates. Moreover, such a positive welfare effect is also likely for an expansion of public expenditures if the prevalent capital income tax level is sufficiently low[26]. In this case, one has to balance the negative effect on first period consumption through higher rates of return to savings with a positive growth effect and higher income levels as productivity

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[26]Note that for $t^r = \bar{t}^r$, the welfare effect is unambiguously positive.

increases. However, with respect to a change in the spending composition in favor of government consumption, there is no scope for a welfare gain similar to the case of inoperative bequests.

To conclude, the welfare implications of the model critically depend on wether bequests are positive or not. In the former case, positive growth effects are accompanied by a welfare gain for the economy provided a sufficiently low level of capital income taxation, while in the latter one the sign of the growth and welfare effects need not necessarily be the same.

4. Conclusions

The focus of this paper is to reexamine the relation between capital income taxation and growth within a one-sector endogenous growth model in which intergenerational transfers take the form of bequests within the family. In this model, a fraction of government spending affects the productivity of private production factors while the remaining part of total tax revenue is allocated to unproductive government consumption. The analysis features three specific policy reforms: First, the additional revenue from an increase of the capital income tax is used to cut wage taxes. Second, the additional revenue is used to enhance productive government spending. Third, the government changes the composition of total government outlays in favor of government consumption.

The analysis extends and generalizes previous studies by Uhlig and Yanagawa (1996) and Rivas (2003). The results of those authors are obtained if bequests are inoperative and the additional revenue from capital income taxation is used either to cut existing wage taxes or to increase the fraction of public services. In these cases, capital income taxation may increase growth, if savings are sufficiently inelastic to changes in the interest rate.

However, if bequests within the family are operative, individuals try to respond to public income redistribution by adjusting private intergenerational transfers. It is shown that this additional channel of private income redistribution overturns the positive growth result due to the shift of the tax burden

but cannot completely offset the positive effect stemming from changes in factor productivity. Moreover, increasing the share of government consumption of total outlays unambiguously reduces growth.

These results are generally driven by three channels: First, they depend on how interest rates and savings react to the respective policy reform. Second, public income redistribution policy affects individual income and thus the individual consumption–saving decision. Third, individuals try to offset public income redistribution by adjusting private transfers. Numerical calibration results using US data underscore the theoretical findings. Yet, in the case of operative bequests, adjusting the tax structure as well as increasing the share of government consumption in total outlays leads to a sharp decline in annual growth rates, while the positive impact of increasing public services is relatively small in absolute values.

In an extension, we also analyze the welfare implications of the different policy reforms. It is found that when bequests are inoperative, positive growth effects coincide with a welfare gain for the economy if the level of capital income taxation is not too high. By contrast, in case of operative bequests, the welfare effects are generally ambiguous depending on the relative strength of the effects of fiscal policy on growth and interest rates. However, a shift of government expenditures in favor of government consumption clearly reduces not only growth but also welfare in any case.

Our analysis suggests at least two things: First, the presence of intergenerational transfers does influence the relation between taxation and growth/welfare. Consequently, one has to be cautious with possible policy implications, as these may vary with the regime in which the economy is operating (operative versus inoperative bequests). Second, from a growth-maximizing point of view, investing in a country's infrastructure seems to be superior to cutting existing wage taxes, irrespective of the presence of private intergenerational transfers. However, if the initial state of the economy is such that bequests are operative, extensive taxation of income from capital may then deliver the largest gains in growth, when tax policy crowds out private transfers within the family.

Finally, an interesting issue of future research would be to analyze the sensitivity of the results with respect to the assumption that public expenditures enter the production function as a flow variable. Alternatively, one could assume public capital to be a stock variable, see, e.g., Turnovsky (1997, 2004). This, however, would further increase analytical complexity.

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Parameter	Value	Source
α	0.4	Uhlig and Yanagawa (1996)
ρ		Chosen to generate an annual growth rate of 2%
λ		To match $x = 0.43$ for given σ—DeLong (2003)
$\tilde{A}$	12	Matches $K/Y = 10.59$—Uhlig and Yanagawa (1996)
A		Chosen to satisfy $\tilde{A}$
t^r	0.35	IRS data—Hendricks (1999)
t^w	0.4	Matches $\kappa = 0.38$—Uhlig and Yanagawa (1996)
ϕ	0.6	Matches total outlays of 22% of GDP

Table 1: Utilized parameter values

				$\sigma = 0.83$		$\sigma = 1$		$\sigma = 1.43$	
t^r	t^w	x	R	g	$\partial g/\partial t^r$	g	$\partial g/\partial t^r$	g	$\partial g/\partial t^r$
0.35	0.4	0.43	1.048	1.020	-1.09	1.02	-1.31	1.02	-1.87
0.4	0.37	0.19	1.046	1.0189	-1.14	1.0187	-1.37	1.0182	-1.94
0.45	0.33	0	1.044	1.0184	1.97	1.0180	1.71	1.0168	1.04
0.5	0.3	0	1.042	1.0203	2.02	1.0196	1.71	1.0178	0.94
0.55	0.27	0	1.039	1.222	2.07	1.0212	1.71	1.0187	0.82

Table 2: Increasing the capital income tax and reducing wage taxes—the effects on the bequest–capital ratio x, the interest factor R, the growth factor g, and its derivative $\partial g/\partial t^r$.

				$\sigma = 0.83$		$\sigma = 1$		$\sigma = 1.43$	
t^r	κ	x	R	g	$\partial g/\partial t^r$	g	$\partial g/\partial t^r$	g	$\partial g/\partial t^r$
0.35	0.38	0.43	1.0483	1.020	0.60	1.02	0.60	1.02	0.62
0.4	0.4	0.27	1.0482	1.0205	0.38	1.0204	0.36	1.0204	0.30
0.45	0.42	0.09	1.0479	1.0207	0.15	1.0207	0.09	1.0205	-0.06
0.5	0.44	0	1.0472	1.0220	2.72	1.0219	2.61	1.0216	2.34
0.55	0.46	0	1.0462	1.0244	2.84	1.0242	2.67	1.0236	2.24

Table 3: Increasing the capital income tax and the share of public spending in GDP—the effects on the bequest–capital ratio x, the interest factor R, the growth factor g, and its derivative $\partial g/\partial t^r$.

			$\sigma = 0.83$		$\sigma = 1$		$\sigma = 1.43$	
ϕ	x	R	g	$\partial g/\partial \phi$	g	$\partial g/\partial \phi$	g	$\partial g/\partial \phi$
0.6	0.43	1.0483	1.020	-4.94	1.02	-5.47	1.02	-6.83
0.65	0.45	1.0432	1.015	-4.72	1.0146	-5.12	1.0133	-6.14
0.7	0.48	1.0376	1.010	-4.48	1.0088	-4.76	1.0060	-5.45
0.75	0.5	1.0316	1.004	-4.21	1.0023	-4.37	0.9980	-4.74
0.8	0.52	1.0251	0.997	-3.91	0.9951	-3.94	0.9893	-4.02

Table 4: Increasing the share of spending in government consumption—the effects on the bequest–capital ratio x, the interest factor R, the growth factor g, and its derivative $\partial g/\partial \phi$.