Is Capital Back?
The Role of Land Ownership and Savings Behavior.

January 14, 2016

Abstract

Wealth inequality is one of the major political concerns in most OECD countries. Under this premise we analyze different policy instruments in terms of their impact on wealth inequality and output. We use a general equilibrium model in which we disaggregate wealth in its capital and land components, and savings in their life-cycle and bequest components. Households are heterogeneous in their taste for the 'warm glow' of leaving bequests. We show that a government has considerable freedom in reducing wealth inequality without sacrificing output: A land rent tax enhances output due to a portfolio effect and reduces wealth inequality slightly. The bequest tax has the highest potential to reduce inequality, and its effect on output is very moderate. By contrast, we confirm the standard result that a tax on capital income reduces output strongly, and show that it only has moderate redistributive effects. Furthermore, we analyze different revenue recycling options and find that lump-sum recycling of the tax revenue to the young generation enhances output the most and further reduces wealth inequality.

JEL Classification: D31, E62, H23, H24, Q24
Keywords: Fiscal policy, Wealth distribution, Economic dynamics, Bequests, Land rent tax

1. Introduction

In many OECD countries wealth-to-income ratios are rising (Piketty and Zucman, 2014) and inequality is relatively high, which is a matter of concern to policy makers. Saez and Zucman (2015) for instance find that the US wealth concentration is high by international standards and has considerably increased in recent decades. To counteract the concentration of wealth Benhabib et al. (2011) and Piketty and Saez (2013)[1] recommend taxes on capital. However, capital taxes discourage investment and reduce economic growth. Further, these authors do not distinguish between capital and wealth (Homburg, 2015), which is inconsistent with empirical findings as Stiglitz (2015) points out. In particular, Stiglitz highlights the fundamental role of land rents for the distribution of wealth.[2] Therefore, we compare taxes on capital income, land rents, and bequests in an overlapping generations model in which we disaggregate wealth into capital and land.

We show that governments have considerable freedom in reducing wealth inequality without sacrificing output. There is a range of combinations of land rent and bequest tax rates under which output remains unchanged, but public revenues and the wealth distribution can be varied.

Explicitly distinguishing the stocks of land and capital is crucial due to their inherently different dynamics. While capital is reproducible, land is fixed. The differing evolution of the capital and housing shares of wealth

[1] Although Piketty and Saez (2013) is titled *A Theory of Optimal Inheritance Taxation*, the tax on bequests which they analyze is equivalent to a capital tax (p. 1854, Footnote 4). Accordingly, the title of their working paper version Piketty and Saez (2012) is *A Theory of Optimal Capital Taxation*.

[2] In contrast to Stiglitz (2015), Homburg (2015) seems to dismiss the distributional implications of the dynamics of land rent ownership in the conclusion of his article.

underline this point: In several developed economies, the increase of the wealth-to-GDP ratio in the post-WWII era is caused by an increase of the value of land (see, e.g., Homburg, 2015, Fig. 3).

In analogy to Piketty and Saez (2013), we choose preferences for bequests as the source of heterogeneity in our analysis. We do so since bequests are a key determinant of wealth inequality (Cagetti and De Nardi, 2008), and intergenerational transfers of wealth make up approximately half of total capital formation (Gale and Scholz, 1994), yet "theoretical implications of inequality in received inheritances are not yet fully understood and are likely to lead to arguments for positive taxation of bequests" (Kopczuk, 2013, p. 332).[3]

Next to Benhabib et al. (2011) and Piketty and Saez (2013) there are many other studies which analyze the distributional effects of taxation in heterogeneous agent models. Two classic papers on optimal taxation, Judd (1985) and Chamley (1986), establish that capital taxes are inefficient, and should not be used to redistribute wealth when households have heterogeneous preferences. More recently, Chiroleu-Assouline and Fodha (2014) implement heterogeneity through differences in skill among workers. They find that if capital taxes (interpreted in their analysis as environmental taxes) are

[3] We are aware of exceptions in the literature: In their empirical contributions Wolff and Gittleman (2014) and Bönke et al. (2015) find that bequests are not an important driver of wealth inequality. However, both studies do not take the top 1% of the wealth distribution fully into account. Further, the results of Wolff and Gittleman (2014) rest on the assumption that "(...) if wealth transfers are eliminated, there would be no effect on the savings behavior of those who have received transfers or are expecting them and that there would be no effect on the savings of those who intend to give a bequest." (p. 465). Due to the methodological difference from Wolff and Gittleman (2014) we are able to take exactly that counterfactual case into account in which transfers are eliminated and households actually change their savings behavior.

regressive, a complementary change of the income tax rules is Pareto efficient and renders the tax system progressive again.

To our knowledge, the only other study with heterogeneous agents that takes land into account apart from ours is Stiglitz (2015). However, the author takes only the polar case of two types of households into account: workers, who save only for consumption during their own old age, and capitalists, who save only to leave bequests to their offspring. He finds that taxing capital income cannot reduce wealth inequality since the capitalists always shift the tax burden to workers.

By contrast, we model heterogeneity in greater detail. We let different households have both savings motives, but to differing degrees. Thus, our framework is flexible enough to be calibrated to the empirical data on the distribution of wealth compiled by the OECD (2015). Due to our assumptions of endogenous saving and bequest heterogeneity instead of class membership, a capital income tax in our model reduces inequality in wealth.

We show that in fact all three instruments considered in our study reduce wealth inequality. However, they differ strongly in their effect on output (and thus also households' incomes). Taxing capital income has a negative effect on output levels for two reasons: The tax reduces households' incentive to save in general, but it also shifts investments away from capital towards land – a macroeconomic portfolio effect. Conversely, land rent taxation shifts private savings and investments away from land and towards capital, thereby enhancing output.[4] Bequest taxes do not affect the composition of the house-

[4] Feldstein (1977) was the first to identify the portfolio effect, which Petrucci (2006) later formalized in an OLG. Edenhofer et al. (2015) extend the analysis of the portfolio effect by introducing a social welfare function as benchmark for evaluating fiscal policy,

holds' portfolio, so they have a significantly smaller effect on output. For the benchmark calibration, bequest taxes reduce output slightly. In that case, the reduction of income is stronger than the increased demand for leaving bequests. In other words, the income effect dominates the substitution effect. In the robustness analysis of our results, however, we also discuss cases in which the opposite is true, and bequest taxes slightly increase output.

Further, the savings behavior of households determines the redistributive effect. Each of the three tax instruments discourages savings to a certain extent, and thus also reduces bequests to the following generation. Since wealthy households' income consists of a relatively high amount of bequests, a reduction of the latter decreases their income more strongly than that of poorer households. The potential to redistribute wealth using land rent and capital income taxation is only moderate compared to bequest taxes, which directly target the source of inequality. Once all land rents are taxed away, or capital investments are choked, respectively, no further redistribution of wealth is possible.

Finally, different ways of recycling tax revenues to the economy have different impacts. Using the tax revenues to finance infrastructure investments only raises the steady state level of output, but does not change the distribution of wealth. If public revenues are instead recycled as lump-sum transfers to households, we find an impact both on output and on the distribution of wealth: The more a government directs the transfers to the young, the

in particular land rent taxes. The present paper focuses on the economic impacts of fiscal policy and does not consider a social welfare function. Nevertheless, we find that under land rent taxation the winners of the policy could theoretically compensate the losers. Thus, land rent taxation fulfills the Kaldor-Hicks criterion (see Appendix D).

higher the level of output in the steady state will be and the more equal wealth will be distributed. Our finding thus gives support to the proposal of the stakeholder society (Ackerman and Alstott, 1999), also voiced by Corneo (2011), Atkinson (2015), and Edenhofer et al. (2015).[5]

The rest of the paper is structured as follows. In Section 2 we introduce a simplified version of our model with sequential generations. Here, we highlight the importance of endogenous prices to justify our choice of a deterministic model with complete markets – an approach which we understand as complementary to Piketty and Saez (2013) and Benhabib et al. (2011), who model individual households' rate of return on capital and the distribution of wealth as determined by stochastic processes. In Section 3 we introduce overlapping generations and land, and perform the policy instrument analysis which is central to our paper. Sensitivity and robustness of our results are tested in Section 4. Section 5 concludes.

[5] Inspired by the idea of the stakeholder society, the United Kingdom introduced Child Trust Funds in 2005, which were replaced by Junior ISAs in 2011.

2. A simple model of bequest heterogeneity

In the present section, we develop a simple model of bequest heterogeneity to explain fundamental mechanisms at work. In particular, we want to demonstrate the importance of the impact of taxes on the interest rate for the distribution of wealth. Land as a production factor and the life cycle savings motive are omitted here and will be introduced in the next section.

Our simple model is based on Acemoglu (2008). To the best of our knowledge, it is the most parsimonious model of an economy in which new generations enter the economy each period and leave bequests to the next generation.

In each period t a new generation arrives in the economy and the old generation leaves the economy. There are N different types of households in each generation, which differ in their preferences. Each type of household $i \in \{1, ..., N\}$ lives for one period, during which it receives income $y_{i,t}$. It divides its income between consumption $c_{i,t}$ and bequests for the next generation $b_{i,t}$, which are taxed at the uniform rate τ_B. A household derives utility from consumption and the "warm glow" (Andreoni, 1989) of leaving net-of-tax bequests:

$$u_{i,t} = \log(c_{i,t}) + \beta_i \log(b_{i,t}(1 - \tau_B)). \tag{1}$$

The budget equation is given by

$$y_{i,t} = w_t + (1 + R_t(1 - \tau_K))b_{i,t-1}(1 - \tau_B) = c_{i,t} + b_{i,t}, \tag{2}$$

where w denotes wage income, R is the rate of return on inherited wealth, that is, the bequests from the previous generation, and $0 < \beta_i < 1$ determines the preference for leaving bequests for the household of type i of the next generation $t+1$. We assume that capital does not depreciate after use,[6] and that the offspring of a household has the same preferences as its parents.[7] Households may have to pay taxes τ_K on capital income or taxes τ_B on the bequests they receive.

Production is given by a standard neoclassical production function in intensive form $f(k)$ that satisfies the usual conditions. Then, for the equilibrium wage rate we have,

$$w_t = f(k_t) - f'(k_t)k_t, \tag{3}$$

and

$$R_t = f'(k_t).$$

[6] Assuming positive depreciation does not alter the results qualitatively.

[7] This simplifying assumption may be justified by recent findings on the determinants of intergenerational wealth transmission which suggest potential roles for intergenerational transmission of preferences (Black et al., 2015).

We assume that all bequests are invested in capital k used for production:

$$k_{t+1} = \frac{1}{N}\sum_i b_{i,t}.$$

2.1. Basic properties

Households choose the levels of consumption and bequests in order to maximize their utility (1) subject to their budget equation (2). This yields the first-order conditions

$$b_{i,t} = \frac{\beta_i}{1+\beta_i} y_{i,t} = \varphi_i \Big(w_t + (1 + R_t(1-\tau_K)) b_{i,t-1}(1-\tau_B) \Big) \quad \forall t, \tag{4}$$

where $i \in \{1, ..., N\}$ and $\varphi_i := \frac{\beta_i}{1+\beta_i}$.

With (4) it is possible to deduce a condition on the curvature of the production function which ensures the existence of a steady state (see Appendix A). This condition is, for instance, fulfilled by CES-type production functions. Then, the steady state level of bequests is given by

$$b_i^* = \frac{w^* \beta_i}{1 + \beta_i - \beta_i \big(1 + R^*(1-\tau_K)\big)(1-\tau_B)}, \tag{5}$$

where asterisks denote steady state levels. Further, if a steady state exists, it follows directly from (5) that households with relatively high preference parameters β_i for bequests have higher steady state levels of bequests than households with relatively low preferences for bequests.[8]

[8] In other words, if $\beta_i > \beta_j$ for $i, j \in \{1, ..., N\}$, then $b_i^* > b_j^*$. To see this, note that

2.2. Fiscal policy

We consider a linear tax on capital income or on bequests which is implemented in the first time period of the model and remains constant for the whole time horizon. The main aim here is to highlight that the impact of the tax on the interest rate is crucial for how the tax affects wealth distribution.

Lemma 1. *Assume a steady state exists (cf. Corollary A, Appendix A).*

1. *An increase in the bequest tax leads to a decrease in wealth inequality, if and only if*

$$\frac{\mathrm{d}R^*}{\mathrm{d}\tau_B} < -\frac{1 + R^*(1-\tau_K)}{(1-\tau_K)(1-\tau_B)}. \tag{6}$$

2. *An increase in the capital income tax leads to a decrease in wealth inequality, if and only if*

$$\frac{\mathrm{d}R^*}{\mathrm{d}\tau_K} < \frac{R^*}{1-\tau_K}. \tag{7}$$

By a decrease in wealth inequality we understand a decreasing steady state bequest ratio b_i^*/b_j^* of households i and j whenever $\beta_i > \beta_j$ (i.e. household i has a higher preference for leaving bequest than household j).

Proof. Let $i, j \in \{1, ..., N\}$ such that $\beta_i > \beta_j$ and thus $b_i^* > b_j^*$ holds. We define $\psi_i := 1+\beta_i - \beta_i\big(1+R^*(1-\tau_K)\big)(1-\tau_B)$. Using (5) it is straightforward to calculate whether a marginal increase of a tax increases or decreases the ratio of steady state bequest levels:

$\frac{\mathrm{d}b_i^*}{\mathrm{d}\beta_i} > 0$ for constant w^* and R^*.

1. $\frac{\mathrm{d}}{\mathrm{d}\tau_B}\left(\frac{b_i^*}{b_j^*}\right) = \overbrace{\frac{\beta_i}{\beta_j}(\beta_i - \beta_j)\psi_i^{-2}}^{>0}\left[\left(1 + R^*(1-\tau_K)\right) + \frac{\mathrm{d}R^*}{\mathrm{d}\tau_B}(1-\tau_K)(1-\tau_B)\right]$

2. $\frac{\mathrm{d}}{\mathrm{d}\tau_K}\left(\frac{b_i^*}{b_j^*}\right) = \underbrace{\frac{\beta_i}{\beta_j}(\beta_i - \beta_j)\psi_i^{-2}(1-\tau_B)}_{>0}\left[\frac{\mathrm{d}R^*}{\mathrm{d}\tau_K}(1-\tau_K) - R^*\right] \quad \square$

The intuition behind conditions (6) and (7) is that wages, which all households receive equally and which are linked to the interest rate R via equation (3), should not decrease too much. If conditions (6) or (7) hold, there is an upper bound for the marginal product of capital $f'(k)$, and thus a lower bound for the capital stock, output, and wages.

Our interpretation of the above lemma is that prices matter for a comprehensive policy instrument analysis. Any statement about the impact of taxes on the distribution of wealth should consider how the taxes affect factor prices endogenously. In Section 3 we will build on this insight to derive more precisely how taxes affect an economy with heterogeneous agents and land when prices are endogenous. Thereby, our study can be understood as complementary to Benhabib et al. (2011) and Piketty and Saez (2013), who assume that the interest rate is exogenously given.

Further note, that Lemma 1 alone does not make a statement whether it is possible to alter the ranking of households' steady-state levels of bequests by fiscal policy.

3. The role of land rents and savings behavior for the economic impact of fiscal policy.

We extend the analytical model described in Section 2 by introducing land and by assuming that agents live for two periods instead of only one. Thus, in each period there are two generations that overlap. We make this assumption to differentiate between the life-cycle savings motive and the savings motive for leaving bequests, and also in order to have a market for land, on which old households may sell their land to young ones. Land thus serves both as a fixed factor of production and an alternative asset for households' investments.

We first give a model description. Then, in Section 3.2, we show how taxes on capital income, land rents, and bequests affect output and the wealth distribution in the steady state, without taking the spending side into account. Finally, in Section 3.3, we consider different ways of using the public funds generated by fiscal policy.

3.1. Model

The economy consists of N different types of households, which differ with respect to their preferences and live for two periods. Further, there is one representative firm and the government. The different preferences of each type of households imply different levels of wealth. Similar to the analytical model of sequential generations in Section 2, we observe that also in the model with overlapping generations, higher preferences for bequests imply higher steady state levels of wealth. For the rest of the paper we set $N = 5$ and use the index i to identify the household belonging to the ith wealth quintile, where households are ordered from lowest to highest preferences for bequests. We assume that the offspring of a household has the same preferences as its parents. Further, we shall assume a finite time horizon, i.e. $t \in \{1, ..., T\}$, where one time step represents a period of 30 years (one generation). All variables are stated in per capita terms.

Households

The utility of households is given by an isoelastic function with elasticity parameter η. It depends on their consumption when young $c^y_{i,t}$, consumption when old $c^o_{i,t+1}$, and net bequests left to their children $b_{i,t+1}(1-\tau_B)$, on which the government may levy bequest taxes.

$$u\left(c^y_{i,t}, c^o_{i,t+1}, b_{i,t+1}\right) = \frac{(c^y_{i,t})^{1-\eta} + \mu_i(c^o_{i,t+1})^{1-\eta} + \beta_i\left(b_{i,t+1}(1-\tau_B)\right)^{1-\eta}}{1-\eta} \tag{8}$$

For the parameters we assume that $\mu_i, \beta_i \in (0, 1)$. Households maximize their utility subject to the following budget equations.

$$\begin{aligned} c^y_{i,t} + s_{i,t} &= w_t + b_{i,t}(1-\tau_B) \\ s_{i,t} &= k^s_{i,t+1} + p_t l_{i,t+1} \\ c^o_{i,t+1} + b_{i,t+1} &= (1 + R_{t+1}(1-\tau_K))k^s_{i,t+1} + l_{i,t+1}(p_{t+1} + q_{t+1}(1-\tau_L)) =: v_{i,t+1} \end{aligned}$$

In period t a young household i earns wage income w_t, receives bequests from the currently old generation, and pays taxes on the bequests. The household uses its income to consume or save. Savings $s_{i,t}$ can be invested in capital $k^s_{i,t+1}$ or land $l_{i,t+1}$, which are assumed to be productive in the next period and may be taxed at rates τ_K and τ_L, respectively. We assume that capital is the numeraire good and land has the price p. When households are old, they receive the return on their investments according to the interest rate R_{t+1}, the price of land p_{t+1}, and the land rent q_{t+1}. We define household wealth $v_{i,t}$ as the sum of the values of the stocks of capital and land, and also the returns to investments in these stocks. Old households use their wealth to consume or to leave bequests for the next generation.

The first-order conditions of the households' optimizations are given by

$$(c^o_{i,t+1})^\eta = \mu_i(1 + R_{t+1}(1 - \tau_K))(c^y_{i,t})^\eta \tag{9}$$

$$\beta_i(1 - \tau_B)^{1-\eta}(c^o_{i,t+1})^\eta = \mu_i b^\eta_{i,t+1} \tag{10}$$

$$\frac{p_{t+1} + q_{t+1}(1 - \tau_L)}{p_t} = 1 + R_{t+1}(1 - \tau_K). \tag{11}$$

Note that the no-arbitrage condition (11) can be reformulated as the discounted sum of future rents:

$$p_t = \sum_{i=1}^{T} \frac{\widetilde{q}_{t+1}}{\prod_{j=T-i+1}^{T}(1 + \widetilde{R}_{t+j})},$$

where $\widetilde{q}_t := q_t(1 - \tau_L)$ and $\widetilde{R}_t := R_t(1 - \tau_K)$, and we assume that in the final period T the price of land is zero, $p_T = 0$, since there is no following generation to buy the land. The no-arbitrage condition ensures that households invest in capital and land in such a way that the returns are equalized across the two assets. The returns are determined by the aggregate quantities of the input factors. Beyond this, the no-arbitrage condition does not impose any restrictions on how the asset portfolios of individual households are composed.[9]

Firm

The representative firm produces one type of final good using capital k, land l and labor, where the latter two are assumed to be fixed factors. We assume that the production function is of CES type. In intensive form it is defined as

$$f(k_t) = A_0[\alpha k_t^\sigma + \gamma l^\sigma + 1 - \alpha - \gamma]^{\frac{1}{\sigma}},$$

where A_0 is total factor productivity and $\sigma = \frac{\epsilon-1}{\epsilon}$ is determined by the elasticity of substitution ϵ. The firm's demand for capital k_t equals the aggregate of capital that is supplied by households $k_{i,t}^s$. The clearing of factor markets is described by

$$k_t = \frac{1}{N}\sum_{i=1}^{N} k_{i,t}^s \quad \text{and} \quad l = \frac{1}{N}\sum_{i=1}^{N} l_{i,t}.$$

In each period the firm maximizes its profit, which we assume to be zero due to perfect competition. Thus, the first-order conditions are

$$f_k(k_t) = R_t \quad \text{and} \quad f_l(k_t) = q_t,$$

and wages are given by $w_t = f(k_t) - R_t k_t - q_t l$.

[9] We shall make use of the convention that all households choose the same asset composition. More precisely, in every period t there is an $X_t > 0$ such that $X_t = k_{i,t}^s / l_{i,t}$ for all $i \in \{1, ..., N\}$. We use this convention because there is an infinite continuum of possible combinations of individual asset portfolio compositions of each household i which have no bearing on any of our results.

Government

The government levies taxes on capital income τ_K, land rents τ_L, or bequests τ_B. Throughout Section 3.2, we assume that public revenues g_t are used for public consumption which has no effect on the economy. In Section 3.3 we relax this assumption and analyze alternative recycling schemes.

$$g_t = \tau_K R_t k_t + \tau_L q_t l + \frac{1}{N}\sum_i \tau_B\, b_{i,t}.$$

3.2. The revenue side of fiscal policy

The heterogeneity in household preferences and the introduction of land as an additional factor of production yield complex results, which go beyond that which is analytically tractable. Thus, we solve the model numerically using GAMS (Brooke et al., 2005). The parameter values are chosen such that the level of output and the distribution of wealth in the steady state match recent OECD data on the distribution of wealth (OECD, 2015).[10] In the present section we focus on the revenue side of fiscal policy and assume that the public revenues are not used for a specific purpose.

The policy-option space of output, redistribution, and public revenue

We evaluate fiscal policy along three dimensions: Their impact on output, their consequences for the wealth distribution, and their potential to raise public revenue.

We summarize our main result in Figure 1. The graphs show the feasible

[10] For a description of the calibration procedure and parameter values, see Appendix B. The robustness of our results with respect to different parametrizations is assessed in Section 4.

combinations of output f^*, the Gini coefficient of the wealth distribution $\{v_i^*\}_{i=1,\dots,5}$, and the magnitude of public revenues g^* in the steady state if only one of the three tax instruments is used at a time. If taxes are set to zero, per capita output is about 1 million US$ per time step (30 years) and the Gini coefficient of the wealth distribution has a value of about 0.63. This point is marked by the intersection of the two dashed lines.

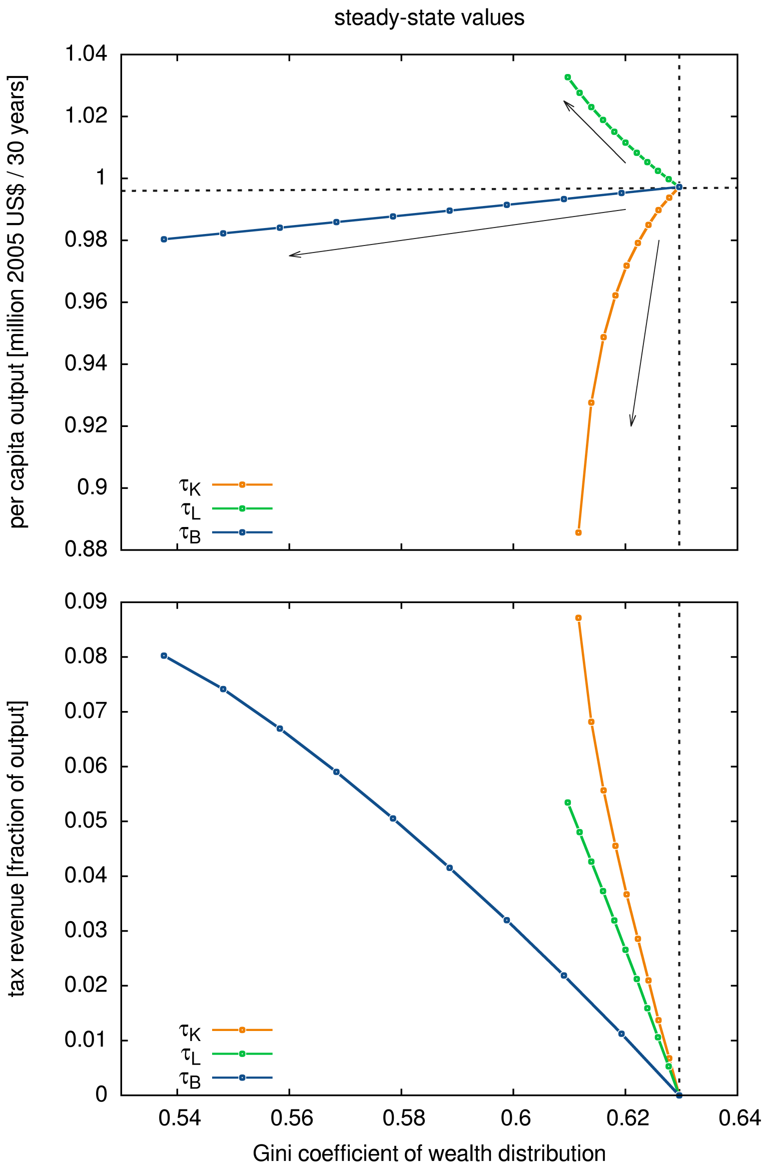

Figure 1: Depending on which tax instrument is used, the government may achieve different coordinates in the policy-option space of output, redistribution, and public revenue. Each curve represents the set of coordinates which are achievable with the use of one single tax instrument. The arrows in the upper panel indicate increases in the respective tax rate. The data points are chosen for tax rates in steps of 10%. They range from 0% to 100% for the land rent tax, and from 0% to 90% for the capital income and the bequest tax. Note that capital income and bequest tax rates of 100% produce extreme results which we have left out here for expositional reasons.

As the tax rates are increased above zero, respectively, we observe that all taxes reduce the Gini coefficient. Output increases under the land rent tax and decreases under the capital income tax. The bequest tax reduces output only slightly. Capital income and bequest taxes achieve higher public revenues than the land rent tax.[11]

The distribution of wealth depends on how fiscal policy affects the two components of the young households' income, i.e., wages and bequests. Rich households draw a higher proportion of their income from bequests than the poor. When a tax affects the two sources of income differently, the distribution of wealth will change accordingly. It turns out that the capital income tax and the land rent tax reduce the after tax return to savings $1 + R^*(1 - \tau_K) = 1 + \frac{q^*}{p^*}(1 - \tau_L)$, which discourages savings and thus reduces bequests. Moreover, bequest taxes reduce households' income, and thus they also reduce bequests via the income effect. Households whose income consists of a comparably high share of bequests are affected more strongly by the bequest tax than households who receive most of their income as wages. As a consequence, each tax instrument reduces the income of richer households by a higher proportion than the income of poorer ones – all taxes have a progressive effect on the distribution of wealth (see Table 1).

[11] In the robustness analysis of our results in Section 4.1.1, we will show that the potential to raise public revenues with the bequest tax crucially depends on the elasticity parameter η of households' utility function.

	Household i	$\tau_K = 0.2$	$\tau_L = 0.2$	$\tau_B = 0.2$	$\tau_K = 0.7$	$\tau_L = 0.7$	$\tau_B = 0.7$
Income y^*							
	1	0.990	1.007	0.995	0.938	1.03	0.98
	2	0.990	1.007	0.995	0.938	1.03	0.98
	3	0.989	1.005	0.989	0.934	1.02	0.96
	4	0.987	1.003	0.975	0.925	1.01	0.91
	5	0.974	0.989	0.910	0.882	0.97	0.73
Bequests b^*							
	1	0.957	0.972	1.014	0.819	0.90	1.03
	2	0.957	0.972	1.014	0.819	0.90	1.03
	3	0.956	0.970	1.008	0.816	0.89	1.01
	4	0.954	0.968	0.994	0.808	0.88	0.97
	5	0.941	0.955	0.928	0.771	0.84	0.77

Table 1: Different tax instruments and rates imply different reductions in the steady state levels of income and bequests. We assume that only one tax is implemented at a time. The numbers give the respective fractions of the case in which no taxes are implemented. All tax instruments reduce the income and the received bequests of rich households by a greater fraction than that of poor households.

The level of output is influenced by households' choices on whether to invest in land or capital. Since land and labor are fixed, fiscal policy that stimulates (hampers) investment in capital will unambiguously increase (decrease) output. While a bequest tax only indirectly affects asset prices, taxes on capital income and land rents have a relatively strong impact. As the relative prices of assets change, households will react by changing the composition of their portfolio.[12] Since the tax on land rents shifts investment toward capital, output actually increases. The capital income tax has the exact opposite effect.

While the observed effects of land rent and capital income taxation are

[12] For a graphical exposition of this fact, see Appendix C, Figure C.1.

quite straightforward, the effects of the bequest tax are governed by the interplay of households' incomes and their substitution behavior. The immediate effect of increasing the bequest tax is to reduce households' income, which follows from the budget equations. A second immediate effect of bequest taxes is that they also increase demand for bequests relative to consumption in both periods of life, which follows from households' first-order conditions.

Table 1 reveals that for relatively rich households the income effect outweighs the substitution effect, while for the poorer households the opposite is true. Since the bequest tax discourages the rich from saving for the purpose of leaving bequests, but encourages the poor to do so,it has a strong potential for wealth redistribution from the rich to the poor. With the bequest tax the Gini coefficient can, thus, be reduced to a significantly lower level than with the taxes on land rents or capital income.

The latter two have natural limits. Once all land rents are taxed away, there is no more scope for further tax increases and wealth redistribution. As capital income taxes are increased, investment in the main source of productivity is choked, and the economy collapses.

Output-neutral tax reform.

Figure 1 suggests that several combinations (τ_L, τ_B) of land rent tax and bequest tax rates can redistribute wealth while at least maintaining the same steady state level of output. In Figure 2 we show how the Gini coefficient changes under different combinations of bequest and land rent tax rates which do not reduce the steady state level of output below the level of the benchmark case in which $\tau_K = 0.2$, and $\tau_L = \tau_B = 0$. The assumed fixed capital income tax rate of 20% is roughly in line with the corresponding average tax rate in OECD countries.

It turns out that a typical OECD government has considerable freedom in choosing the desired value of the Gini coefficient without having to bear any costs in terms of forgone output. In our experiment, the Gini coefficient may be reduced from its benchmark value 0.63 down to almost 0.52, and public revenues increase from 1.4% to about 11% of output, as Table 2 shows.

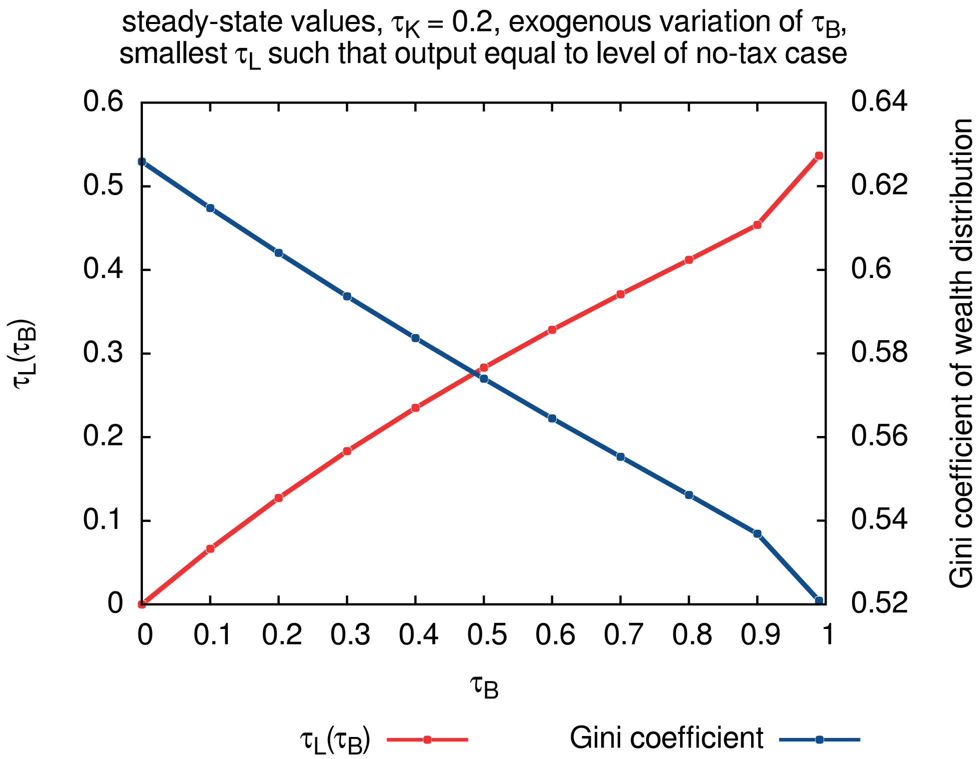

Figure 2: Combinations of bequest- and land rent taxes that imply the same steady-state level of output as in the benchmark case in which $\tau_K = 0.2, \tau_L = \tau_B = 0$.

τ_B	τ_L	Gini	public revenue per capita [10^3 2005 US$/30 years]	[fraction of output]
0.00	0.00	0.63	14	1.4%
0.10	0.07	0.62	28	2.8%
0.20	0.13	0.60	40	4.0%
0.30	0.18	0.59	52	5.3%
0.40	0.24	0.58	63	6.4%
0.50	0.28	0.57	73	7.4%
0.60	0.33	0.57	82	8.3%
0.70	0.37	0.56	91	9.2%
0.80	0.41	0.55	98	9.9%
0.90	0.45	0.54	105	10.6%
0.999	0.54	0.52	104	10.5%

Table 2: Combinations of bequest and land rent taxes that imply the same steady-state level of output ($f^* = 0.99$ million 2005 US$ / 30 years) as in the benchmark case in which $\tau_K = 0.2, \tau_L = \tau_B = 0$.

3.3. The spending side of fiscal policy

So far, we have only considered the revenue side of fiscal policy. Thereby we have assumed that the public revenues do not feed back into the economy. However, since public revenues are an endogenous variable and can become quite substantial, we now turn to the analysis of alternative uses of these revenues. Here, we show how different ways of recycling the revenues as lump-sum transfers to young and old households affect the policy-option space. In Section 4.2, we also consider the alternative case of productivity enhancing public spending, for example through infrastructure investments.

Lump-sum transfers to young and old households

We analyze the impacts of different transfer schemes by varying the distribution parameter $\delta \in [0, 1]$. Its value indicates the fraction of total transfers going to the old generation. Now, the budget equations of the young and the old households living in period t are given by

$$c^y_{i,t} + s_{i,t} = w_t + b_{i,t}(1 - \tau_B) + (1 - \delta)g_t,$$
$$c^o_{i,t} + b_{i,t} = (1 + R_t(1 - \tau_K))k^s_{i,t} + l_{i,t}(p_t + q_t(1 - \tau_L)) + \delta g_t.$$

As Figure 3 shows, it makes a significant difference whether the government transfers the public revenues only to young households ($\delta = 0$), only to old households ($\delta = 1$), or to both[13]. The more the government directs transfers to the young, the higher the level of output in the steady state will be and the more equal wealth will be distributed.

If a transfer increases a young household's income, it directly increases consumption as well as savings (an income effect), and thus also capital supply and output. By contrast, a transfer to old households can in principle increase savings only indirectly. Through the direct income effect the old consume more and leave more bequests. Leaving more bequests, as second-order effect, increases the income of the descendants. If bequests are taxed, then the second-order increase of the income of descendants is even smaller. However, it turns out that transfers to the old actually reduce savings through a substitution effect: Since young households anticipate the higher income in old age, they save less. The substitution effect is stronger for those households that have relatively low preferences for leaving bequests (and, thus, for savings). An overcompensation of the income effect through the substitution effect explains why the Gini coefficient increases and the output level

[13]Here, we use $\delta = \frac{1}{2}$. In general, of course, any $0 < \delta < 1$ implies transfers to both.

decreases with δ.

It is worth mentioning that there is a relatively low threshold for the percentage of transfers which go to the old ($0 < \delta < 0.5$) above which the substitution effect is so strong, that steady state output falls below the case in which public revenues are not even fed back into the economy (see Appendix C, Figure C.3).

If the government uses the bequest tax, public revenues are highest under recycling scheme $\delta = 1$. The more transfers are directed to the young, the lower the bequest tax revenues become. Revenues from land rent and capital income taxes show no substantial change under variation of δ.[14] This difference is due to the fact that, unlike with the factor taxes, the choice of the redistribution parameter δ directly changes the tax base of the bequest tax.

[14] See Appendix C, Figure C.2 for a graphical exposition of this fact.

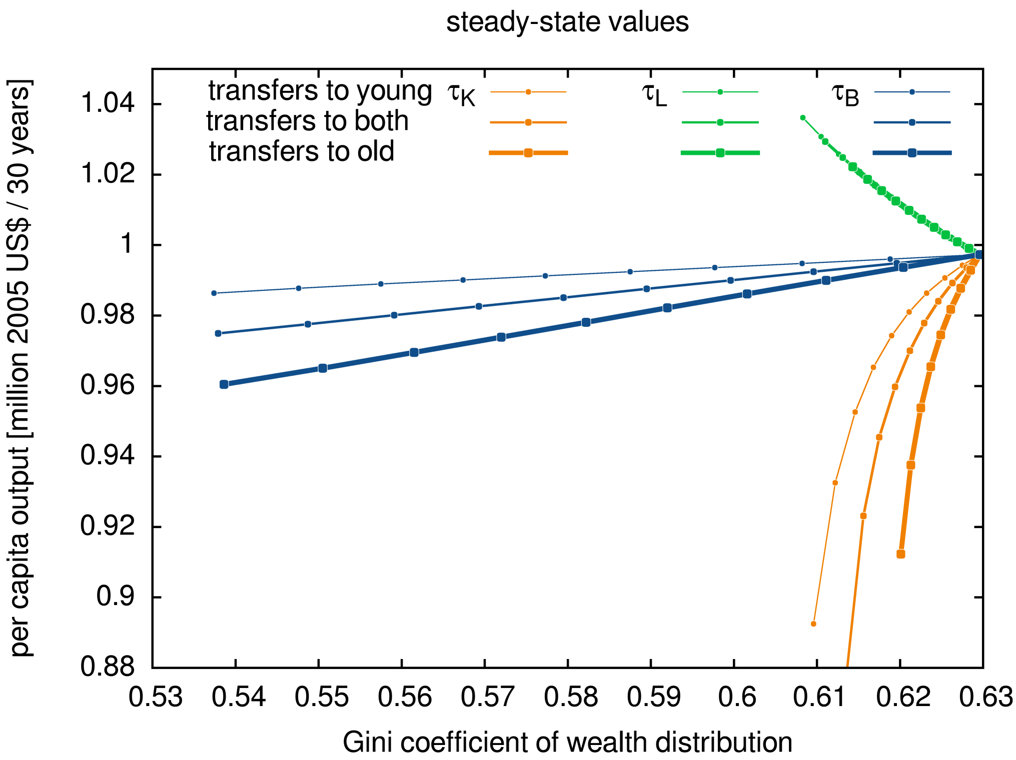

Figure 3: Impact of different recycling schemes on output and the distribution of wealth.

4. Robustness checks and sensitivity analysis

This section shows the robustness of our main results with respect to different assumptions about model specifications. In Section 4.1, we describe how the policy option space (cf. Figure 1) changes under different parameter choices. Then, in Section 4.2, we discuss the alternative assumption that the government finances infrastructure investments with the tax revenues – instead of recycling them as lump-sum transfers.

4.1. Sensitivity analysis of the impacts of fiscal policy

We have calibrated the model parameters to match observed data on the distribution of wealth in OECD countries (OECD, 2015) under the assumption that the capital income tax rate τ_K is 20%, while land and bequests are not taxed – we shall refer to this as the standard policy case. To test the sensitivity of our results to the parameter choice, we have performed a one-at-a-time variation of all model parameters. For each variation of one specific parameter we have subsequently recalibrated all other parameters such that the standard policy case reproduces the observed data again.

For most tested parameters, we find that a variation has no significant qualitative nor quantitative effect on our results. However, the elasticity parameters of the utility function η and of the production function ϵ reveal a non-trivial relationship between parameter choice and model results. Thus, in the following we only present the results of separate variations of η and ϵ. Neither the simultaneous variation of the latter two parameters, nor simultaneous variations of multiple other randomly chosen parameters provided any further insights.

Utility function

The elasticity parameter of the utility function η has a significant impact on the distribution of wealth and, moreover, on output, even when taxes are not taken into account (see Figure 4). Ceteris paribus, the steady state level of output increases with η, while the Gini coefficient decreases. The reason is that households' substitution behavior depends on η. The first-order conditions (9) and (10) determine the relative demand for consumption and bequests. It turns out that higher values of η induce poorer households to save more, while it does not discourage rich households from leaving bequests significantly. Taken together, total wealth increases, in particular capital, and thus also output.

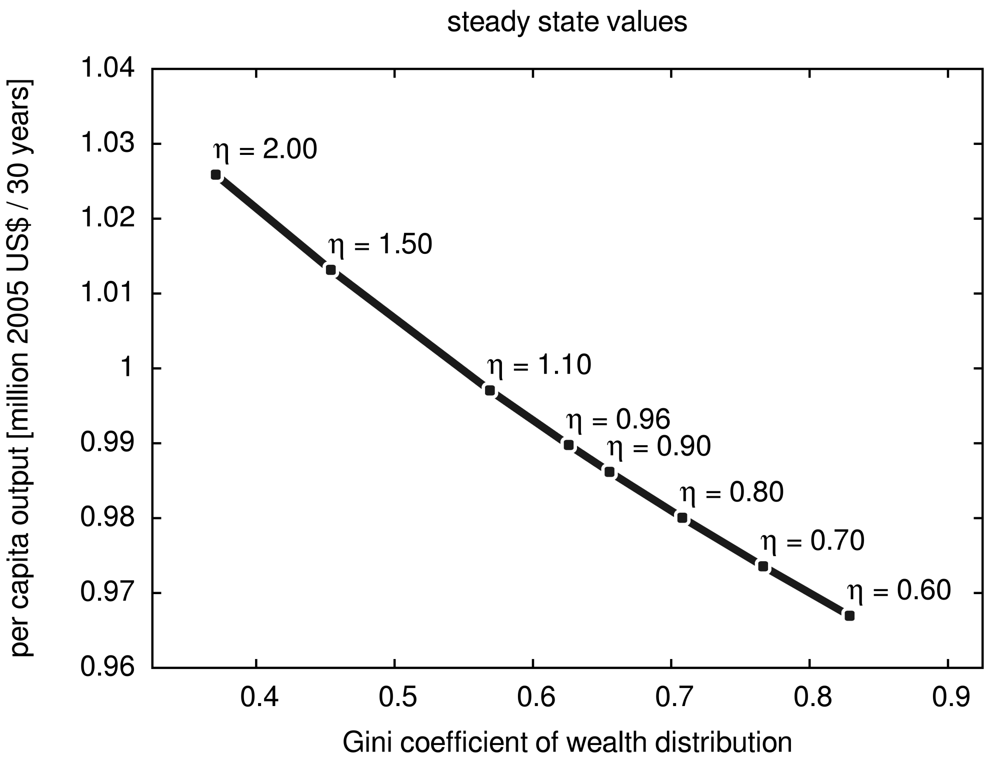

Figure 4: Variation of preference parameter η without recalibration to observed data. Benchmark case: $\eta = 0.96$.

Now, consider the parameter variation under recalibration of all other parameters. Figure 5 shows that the behavior of the economy in reaction to fiscal policy is sensitive to changes in the elasticity parameter. First, note that the potential to redistribute wealth with the capital income or the land rent tax increases with the elasticity parameter η. This is because increasing η implies that the tax-induced reduction in the after tax rate of return to savings $1+R^*(1-\tau_K) = 1+\frac{q^*}{p^*}(1-\tau_L)$ induces a stronger behavioral response. This means that for higher η, households reduce their savings more strongly in reaction to increases in capital income or land rent taxes. As discussed in Section 3.2.1, richer households' incomes are thus reduced by a higher factor than poorer households' incomes.

In contrast, the government's scope for wealth redistribution via the bequest tax decreases as η increases. The bequest tax is progressive due to the income effect it induces.[15] For higher values of η, however, the substitution effect gains in importance relative to the income effect, and thus, the bequest tax becomes less progressive.

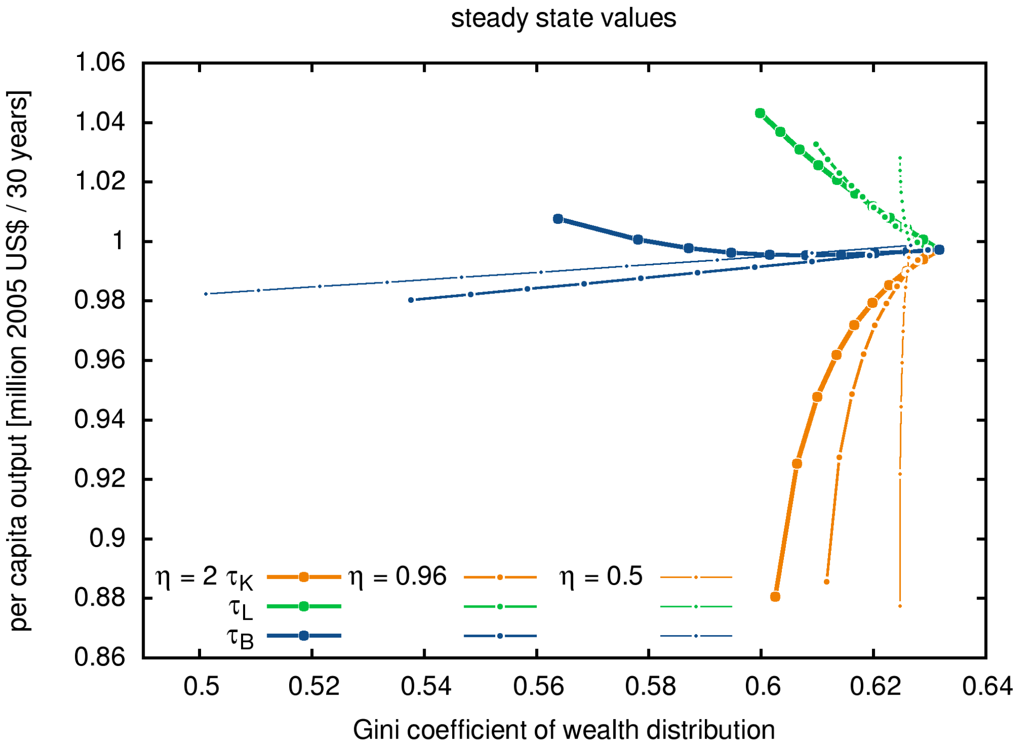

Figure 5: Policy-option space under variation of preference parameter η and subsequent recalibration of all other parameters such that the case of $\tau_K = 0.2, \tau_L = \tau_B = 0$ remains invariant under the variation of η.

Further, Figure 5 reveals that reactions to the bequest tax in term of

[15] As explained in Section 3.2.1, rich households' income includes a higher proportion of bequests. Bequest taxes thus reduce their income by a higher factor than the incomes of poorer households.

steady-state levels of output are qualitatively different for different values of η. When η is relatively high, the bequest tax has the tendency to increases output, in particular for higher tax rates. The opposite is the case for lower values. The variation illustrated in Figure 5 shows us how η determines the relative size of income and substitution effects of the bequest tax (see also the discussion in Section 3.2.1). For high η, the tax-induced substitution effect outweighs the income effect, households redirect their income away from consumption towards leaving bequests. Thereby they save more, which implies more capital, and thus a higher output level. For low η the opposite is the case.

Finally, in Figure 6 we see that the potential to raise public revenues with the bequest tax τ_B strongly depends on the choice of the elasticity parameter η. The higher η is, the greater the revenue raising potential of the bequest tax becomes. In contrast, revenues from capital income and land rent taxation remains almost unchanged when η changes.

The mechanism that drives this behavior is again the interplay of the income and substitution effects. For a high elasticity parameter η, the substitution effect outweighs the income effect. In that case, increasing the bequest tax also increases the demand for leaving bequests, and thus increases the tax base. In analogy, for low values of η, the opposite is the case.

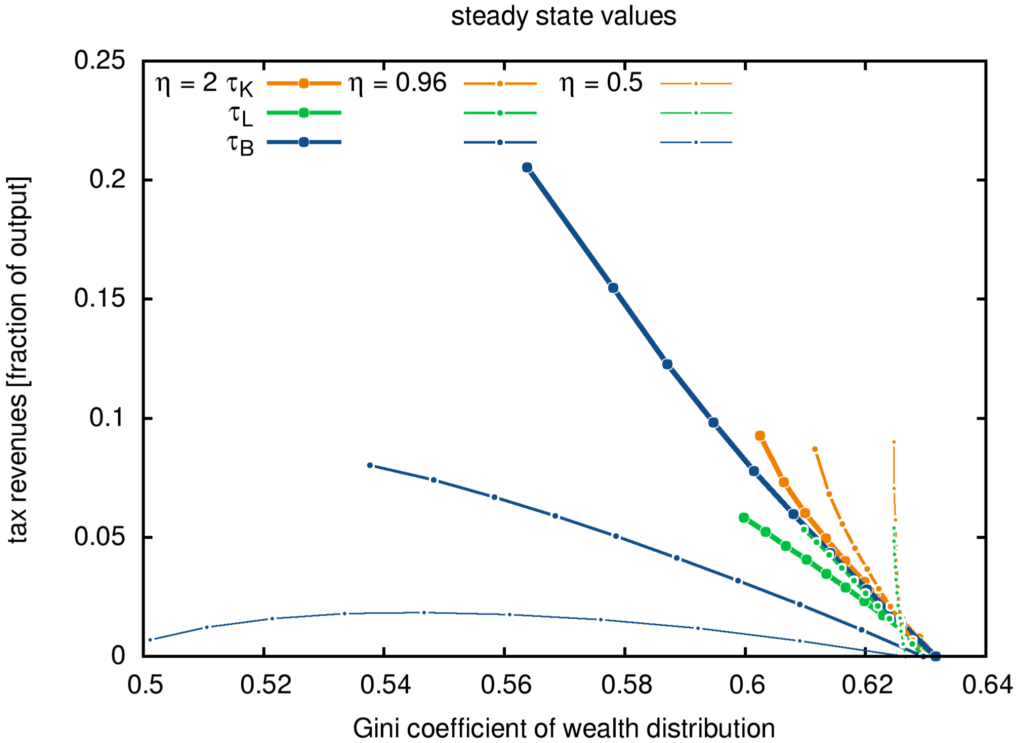

Figure 6: Tax revenues and Gini coefficient under variation of preference parameter η and subsequent recalibration of all other parameters such that the case of $\tau_K = 0.2, \tau_L = \tau_B = 0$ remains invariant under the variation of η.

Production function

Figure 7 shows that varying the substitution elasticity ϵ (and subsequently recalibrating all other parameters) has no greater qualitative impact. However, the graph shows clearly the intuitive result that varying the elasticity does change the results quantitatively. The higher the substitution elasticity is, the greater is the impact of bequest and capital income taxes on output and the wealth distribution. In contrast, the impact of land rent taxation on the wealth distribution is slightly reduced.

Varying ϵ changes the elasticity of capital supply with respect to capital income and bequest taxes. Hence, we observe a relatively strong increase in the impact of the two instruments if ϵ is increased. Since land is a fixed factor, changes in the effects of land rent taxation are much less pronounced when ϵ is varied.

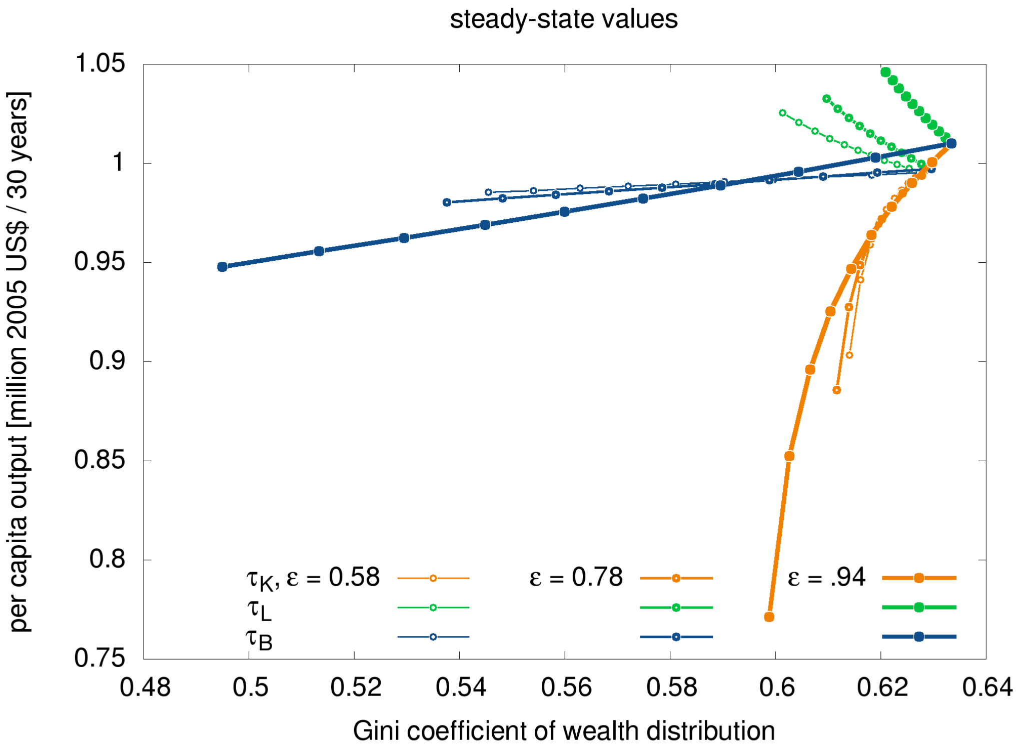

Figure 7: Policy-option space under variation of substitution elasticity ϵ and subsequent recalibration of all other parameters such that the case of $\tau_K = 0.2, \tau_L = \tau_B = 0$ remains invariant under the variation of ϵ. Benchmark case: $\epsilon = 0.78$.

The elasticity of substitution determines the potential to raise public revenues in a similar way (see Figure 8 and Table 4 in Appendix C). Thus, the potential of the land rent tax remains invariant. Under relatively high values of ϵ, the bequest tax has a higher tendency to erode its tax base. Consequently, increasing ϵ reduces the tax revenues collected with the bequest tax. Finally, the capital tax also erodes its tax base more strongly under higher values of ϵ. However, the decrease of the capital stock k^* is less than the increase of the interest rate $R^* = f_k(k^*)$. Therefore, capital income tax revenues $k^* R^* \tau_K$ increase if the elasticity of substitution ϵ increases.

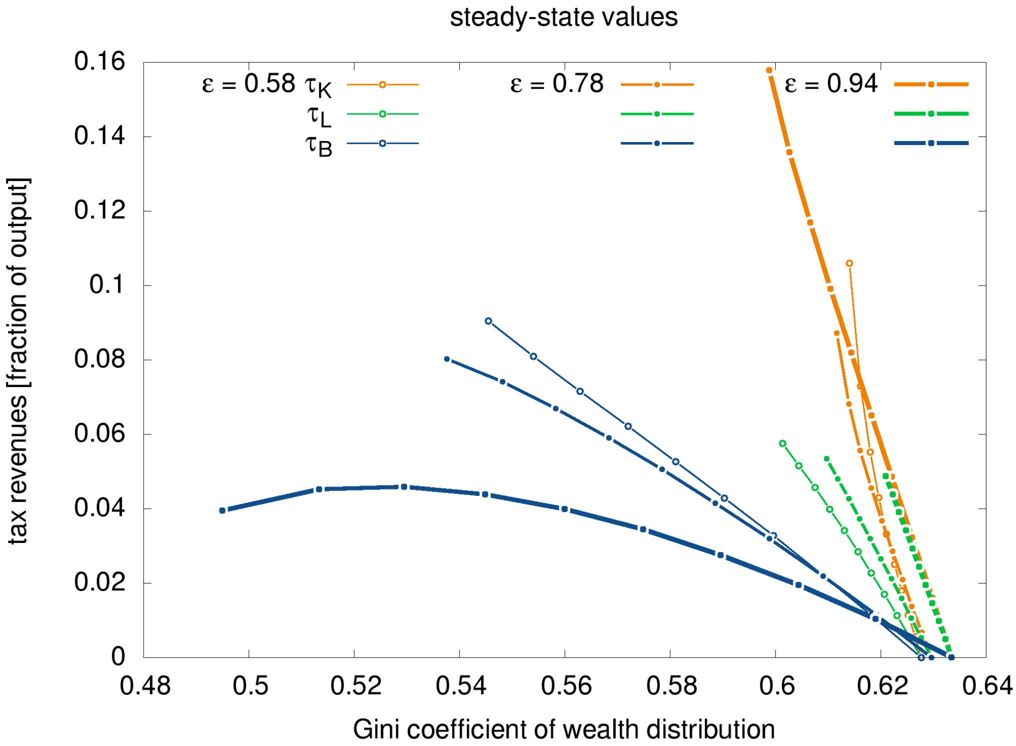

Figure 8: Tax revenues and Gini coefficient of wealth distribution under variation of substitution elasticity ϵ and subsequent recalibration of all other parameters such that the case of $\tau_K = 0.2, \tau_L = \tau_B = 0$ remains invariant under the variation of ϵ. Benchmark case: $\epsilon = 0.78$.

4.2. Alternative spending option: Infrastructure investments

In Section 3.3 we considered different ways of recycling tax revenues as lump-sum transfers to the households. Here, we briefly show how results change under the alternative assumption that the government spends tax revenues to enhance firms' productivity, for example through infrastructure investments. In the following, we assume a simple linear relationship between public revenues and total factor productivity A:

$$A_t = A_0 + x_1 g_t$$

The impact of varying the efficiency parameter x_1 on output and the distribution of wealth are summarized in Figure 9. Independent of which tax instrument is used, an increase in the efficiency of public expenditures also increases the steady state level of output.

While output is quite sensitive to changes in x_1, the wealth distribution remains almost unchanged. The reason is that increasing x_1 raises incomes for all types of households equally. The so-caused increase in total factor productivity does not only increase wages, but also the return on savings. In sum, the incomes of all households increase by almost the same factor and the wealth distribution remains virtually unchanged.

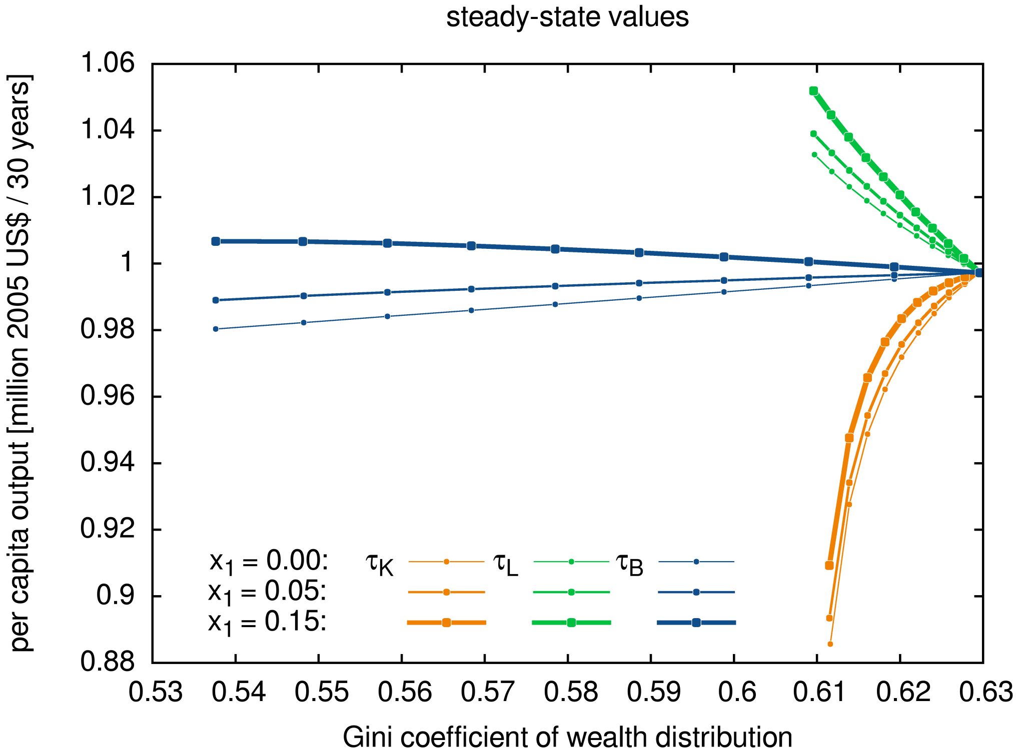

Figure 9: Impact of different degrees of effectivity of infrastructure on output and the wealth distribution

5. Conclusion

Is capital back? Thomas Piketty and Gabriel Zucman claim that this is the case by highlighting that the currently observed increased levels of inequality are due to a concentration of capital ownership at the top (Piketty, 2014, Piketty and Zucman, 2014). Recent literature, however, suggests that land ownership and bequest heterogeneity play a more important role in the process of wealth concentration (Homburg, 2015; Stiglitz, 2015; Cagetti and De Nardi, 2008). We illustrate this in an overlapping generations model that accounts for both features.

Our conclusions differ from Piketty's. Life-cycle saving (when invested in capital) should be left untaxed, while taxing bequests has a higher scope for redistribution at lower policy costs. Further, taxing the land rent component of wealth has a moderate scope for redistribution and strongly enhances output, due to a beneficial portfolio effect: Households shift investments away from the fixed factor land towards capital. The increase in capital investments directly increases output. Accordingly, capital income taxes reduce output since they discourage capital investments.

Atkinson (2015) takes up the idea of the stakeholder society (Ackerman and Alstott, 1999) and proposes, among other measures, to reduce inequality by endowing young households with a one-time transfer at adulthood. That transfer, according to Atkinson, should be financed by a wealth or inheritance tax. We demonstrate that financing such a transfer indeed reduces inequality. We find that the more the transfers are directed to the young and the less they are directed at the old, the higher output in steady state is and the more equal the wealth distribution is. In this case, reducing inequality goes hand in hand with enhancing output.

While heterogeneity in bequests is a key driver of the wealth distribution, it is not the only one which has been suggested by the literature. Entrepreneurial risk taking, income inequality, or the type of earnings risk at the top of the distribution (Cagetti and De Nardi, 2008; De Nardi, 2015), as well as differences in education (Pfeffer and Killewald, 2015) also may play an important role in determining the shape of the distribution and how it changes over time. The quantitative importance of each factor is still an open research question, and the design of tax policies crucially depends on its answer. Accordingly, our results will differ from findings based on other assumptions about the drivers of wealth inequality. Extending our analysis of policy instruments to a framework with multiple drivers of wealth inequality, as used for instance by De Nardi and Yang (2014), could yield valuable insights.

There is a further promising avenue for future research based on the present article. The policy instrument analysis conducted here has focused only on the impact of exogenously determined tax reforms on the steady state. It would be desirable to embed our analysis within a framework of optimal taxation and social welfare maximization, and thus combine the theory of optimal taxation with the literature on household heterogeneity.

References

Acemoglu, D., 2008. Introduction to modern economic growth. MIT Press.

Ackerman, B., Alstott, A., 1999. The stakeholder society. Yale University Press.

Andreoni, J., 1989. Giving with impure altruism: applications to charity and Ricardian equivalence. The Journal of Political Economy , 1447–1458.

Atkinson, A.B., 2015. Inequality: What Can Be Done? Harvard University Press.

Benhabib, J., Bisin, A., Zhu, S., 2011. The Distribution of Wealth and Fiscal Policy in Economies With Finitely Lived Agents. Econometrica 79, 123–157.

Black, S.E., Devereux, P.J., Lundborg, P., Majlesi, K., 2015. Poor Little Rich Kids? The Determinants of the Intergenerational Transmission of Wealth. Working Paper 21409. National Bureau of Economic Research.

Brooke, A., Kendrick, D., Meeraus, A., Raman, R., Rosenthal, R., 2005. GAMS – A Users Guide. GAMS Development Corporation.

Bönke, T., Corneo, G., Westermeier, C., 2015. Erbschaft und Eigenleistung im Vermögen der Deutschen: Eine Verteilungsanalyse. Discussion Papers 2015/10. Free University Berlin, School of Business & Economics.

Cagetti, M., De Nardi, M., 2008. Wealth inequality: Data and models. Macroeconomic Dynamics 12, 285–313.

Chamley, C., 1986. Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives. Econometrica 54, 607–622.

Chiroleu-Assouline, M., Fodha, M., 2014. From regressive pollution taxes to progressive environmental tax reforms. European Economic Review 69, 126–142.

Corneo, G., 2011. Stakeholding as a new development strategy for Saudi Arabia. Review of Middle East Economics and Finance 7, 1–19.

De Nardi, M., 2015. Quantitative Models of Wealth Inequality: A Survey. Working Paper 21106. National Bureau of Economic Research.

De Nardi, M., Yang, F., 2014. Bequests and heterogeneity in retirement wealth. European Economic Review 72, 182–196.

Edenhofer, O., Mattauch, L., Siegmeier, J., 2015. Hypergeorgism: When rent taxation is socially optimal. FinanzArchiv: Public Finance Analysis 71, 474–505.

Feldstein, M., 1977. The surprising incidence of a tax on pure rent: A new answer to an old question. The Journal of Political Economy 85, 349–360.

Gale, W.G., Scholz, J.K., 1994. Intergenerational Transfers and the Accumulation of Wealth. The Journal of Economic Perspectives 8, 145–160.

Homburg, S., 2015. Critical remarks on Piketty's Capital in the Twenty-first Century. Applied Economics 47, 1401–1406.

Judd, K.L., 1985. Redistributive taxation in a simple perfect foresight model. Journal of Public Economics 28, 59–83.

Kopczuk, W., 2013. Taxation of Intergenerational Transfers and Wealth, in: Auerbach, A.J., Chetty, R., Feldstein, M., Saez, E. (Eds.), Handbook of Public Economics, Volume 5. Newnes.

OECD, 2015. In It Together: Why Less Inequality Benefits All. OECD Publishing, Paris.

Petrucci, A., 2006. The incidence of a tax on pure rent in a small open economy. Journal of Public Economics 90, 921–933.

Pfeffer, F.T., Killewald, A., 2015. How Rigid is the Wealth Structure and Why? Inter-and Multigenerational Associations in Family Wealth. Research Report 15-845. Population Studies Center.

Piketty, T., 2014. Capital in the 21st Century. Belknap Press.

Piketty, T., Saez, E., 2012. A Theory of Optimal Capital Taxation. Working Paper 17989. National Bureau of Economic Research.

Piketty, T., Saez, E., 2013. A theory of optimal inheritance taxation. Econometrica 81, 1851–1886.

Piketty, T., Zucman, G., 2014. Capital is Back: Wealth-Income Ratios in Rich Countries 1700–2010. The Quarterly Journal of Economics 129, 1255–1310.

Saez, E., Zucman, G., 2015. Wealth inequality in the United States since 1913: Evidence from capitalized income tax data. Technical Report. Center for Equitable Growth, UC Berkeley.

Stiglitz, J.E., 2015. New Theoretical Perspectives on the Distribution of Income and Wealth among Individuals: Part III: Life Cycle Savings vs. Inherited Savings. Working Paper 21191. National Bureau of Economic Research.

Wolff, E.N., Gittleman, M., 2014. Inheritances and the distribution of wealth or whatever happened to the great inheritance boom? The Journal of Economic Inequality 12, 439–468.

A. Mathematical tools

Here we develop some mathematical tools to analyze the simple model from Section 2.

Lemma A. *If there exists a period t' such that for all $i \in \{1, ..., N\}$ it holds that $b_{i,t'} = b_{i,t'+1} > 0$, then there are b^* and k^* such that $k_{t'+l} = k^*$ and $b_{i,t'+l} = b_i^* \quad \forall l \geq 1$.*

Proof. Let t' be such that $b_{i,t'} = b_{i,t'+1} \ \forall i$. Then it follows that

$$k_{t'+2} = \frac{1}{N} \sum_i b_{i,t'+1} = \frac{1}{N} \sum_i b_{i,t'} = k_{t'+1},$$

which implies $w_{t'+1} = w_{t'+2}$ and $R_{t'+1} = R_{t'+2}$. Using this we have

$$\begin{aligned}
b_{i,t'+2} &= \varphi_i\Big(w_{t'+2} + (1 + R_{t'+2}(1 - \tau_K))b_{i,t+1}(1 - \tau_B)\Big) \\
&= \varphi_i\Big(w_{t'+1} + (1 + R_{t'+1}(1 - \tau_K))b_{i,t}(1 - \tau_B)\Big) \\
&= b_{i,t'+1}.
\end{aligned}$$

The iteration of these two steps closes the proof. □

□

Corollary A. *If the condition*

$$\lim_{k \to \infty} f''(k)(\beta_i f(k) - k) = 0 \tag{12}$$

holds for all i (e.g., when the production function is of CES- or Cobb-Douglas type), there exists a steady state with capital-labor ratio k^*, bequest levels $b_i^* = \frac{w^* \beta_i}{1-\beta_i R^*}$, and factor prices w^*, R^*.

Proof. Considering Lemma A we have to show that for some $t' \in \mathbb{N}$ the equations

$$b_i := b_{i,t'} = b_{i,t'+1} > 0, \quad i \in \{1, ..., N\} \tag{13}$$

have a solution, respectively. To see this, we use Equation (4), which states that

$$b_{i,t'+1} = \varphi_i \Big(w_{t'+1} + (1 + R_{t'+1}(1 - \tau_K)) b_{i,t}(1 - \tau_B) \Big).$$

W.l.o.g. we assume that $\tau_B = 0 = \tau_K$. Plugging in Equation (13), we have

$$\begin{aligned} & b_i = \varphi_i (w_{t'+1} + (1 + R_{t'+1}) b_i) \\ \iff \quad & b_i = \frac{\varphi_i w_{t'+1}}{1 - \varphi_i (1 + R_{t'+1})} \quad \forall i. \end{aligned} \tag{14}$$

When Equation (13) holds, we always have $\varphi_i(1 + R_{t'+1}) < 1$. This can be seen by using Equation (4), from which follows that

$$b_i = \varphi_i(w_{t'+1} + (1 + R_{t'+1})b_i) \iff (1 + R_{t'+1})b_i\varphi_i = b_i - \varphi_i w_{t'+1},$$
$$\iff (1 + R_{t'+1})\varphi_i = 1 - \underbrace{\frac{\varphi_i w_{t'+1}}{b_i}}_{>0} < 1. \qquad (15)$$

It remains to be shown that under condition (12) the Equations (14) have a solution. To see this, let's define

$$\psi(b_i) := \frac{\varphi_i w_{t'+1}}{1 - \varphi_i(1 + R_{t'+1})}.$$

Due to constant returns to scale in the production function we have

$$\psi(b_i) = \varphi_i \frac{f(k_{t'+1}) - f'(k_{t'+1})k_{t'+1}}{1 - \varphi_i(1 + f'(k_{t'+1}))}.$$

It is straightforward to calculate the first derivative of ψ with respect to b_i. Note that $k_{t'+1} = \frac{1}{N}\sum_j b_j$, so $\frac{\mathrm{d}}{\mathrm{d}b_i}k_{t'+1}(b_i) = \frac{1}{N}$. Thus it holds that

$$\psi'(b_i) = \underbrace{\frac{\varphi_i f''(k_{t'+1})}{(1 - \varphi_i(1 + f'(k_{t'+1})))^2 N}}_{<0} \left[\varphi_i f(k_{t'+1}) - k_{t'+1}(1 - \varphi_i)\right],$$

and

$$\psi'(b_i) \begin{cases} > 0\,, & \text{if } 0 > \varphi_i f(k_{t'+1}) - k_{t'+1}(1-\varphi_i) \\ = 0\,, & \text{if } 0 = \varphi_i f(k_{t'+1}) - k_{t'+1}(1-\varphi_i) \\ < 0\,, & \text{if } 0 < \varphi_i f(k_{t'+1}) - k_{t'+1}(1-\varphi_i) \end{cases}$$

Due to the monotonicity of the production function, there is only one non-zero value of $k_{t'+1}$ at which it is equal to $\frac{\varphi_i}{1-\varphi_i} f(k_{t'+1})$. Thus, as b_i increases from 0 on, ψ first falls monotonically, then reaches its minimum, and from then on increases monotonically. Depending on the values of the other b_j, $j \neq i$, the capital stock $k_{t'+1}$ could already be greater than $\varphi_i f'$ when $b_i = 0$. Now taking the limit of ψ', we see that

$$\lim_{b_i \to \infty} \psi'(b_i) = \lim_{b_i \to \infty} \frac{\beta_i}{N} f''(\beta_i f - k_{t'+1}).$$

So if Equation (12) holds, then ψ approaches some constant value. From Equation (15) we know that ψ is always positive. Thus, it must have at least one intersection with the function that maps b_i to itself, which is equivalent to the existence of a solution to Equation (14). $\square$

B. Model parameters and calibration

To calibrate the model, we fix the steady state levels of output and wealth to average OECD data (OECD, 2015), the capital income tax rate at its approximate OECD average, and set the land rent and bequest tax rates to be zero. Then we solve for the parameters which describe household preferences and production technology. Table 3 summarizes these values.

The calibration algorithm is implemented as an optimization problem. More precisely, we find the preference and technology parameters by minimizing the weighted sum of the Euclidean norm of the differences between the OECD data and the steady state levels of output and wealth.

Preferences	Elasticity parameter	η	0.96
	Preferences for consumption when old	μ_1	0.070
		μ_2	0.070
		μ_3	0.095
		μ_4	0.152
		μ_5	0.468
	Preferences for leaving bequests	β_1	0.0001
		β_2	0.0001
		β_3	0.025
		β_4	0.082
		β_5	0.398
Production	Share parameter of capital	α	0.2
	Share parameter of land	γ	0.08
	Elasticity of substitution	ϵ	0.78
	Total factor productivity	A_0	481.9
Tax rates	Capital income tax	τ_K	0.2
	Land rent tax	τ_L	0
	Bequest tax	τ_B	0
Other	Time horizon	T	40

Table 3: Benchmark parameters that reproduce observed data on the wealth distribution in OECD countries.

C. Additional figures and data

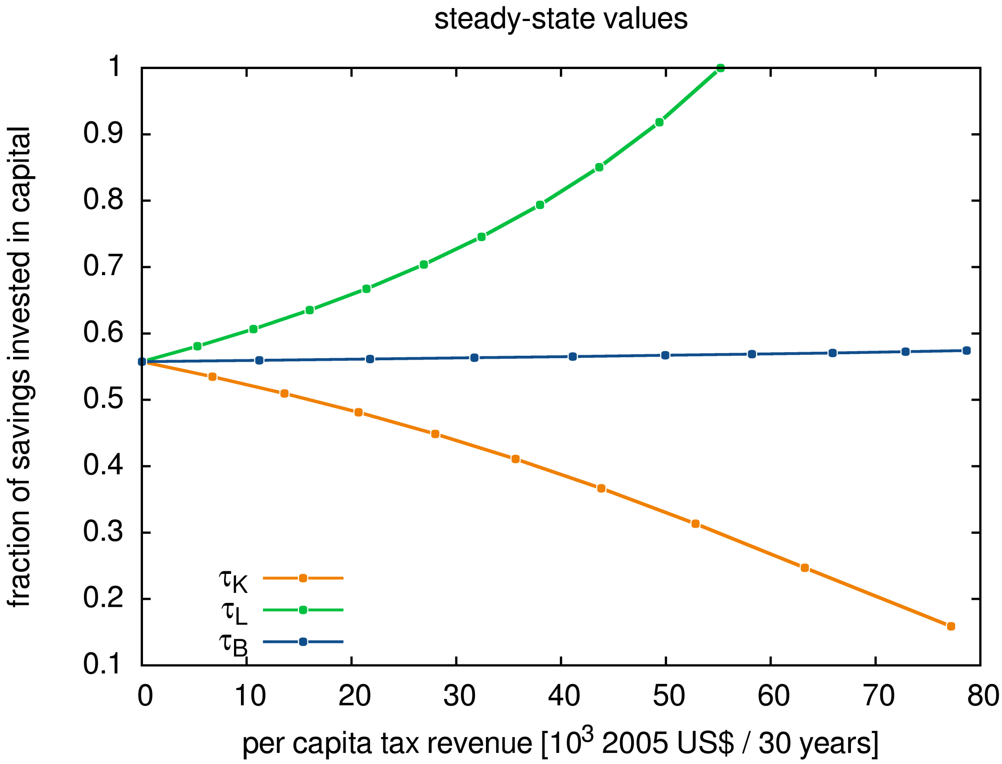

Figure C.1: Aggregate composition of assets (cf. Footnote 12) under variation of fiscal policy. Fiscal policy that stimulates (hampers) investment in capital will unambiguously increase (decrease) output. While a bequest tax only indirectly affects asset prices, taxes on capital income and land rents have a relatively strong impact. As the relative prices of assets change, households react by changing the composition of their portfolio. Since the tax on land rents shifts investment toward capital, output actually increases. The capital income tax has the exact opposite effect.

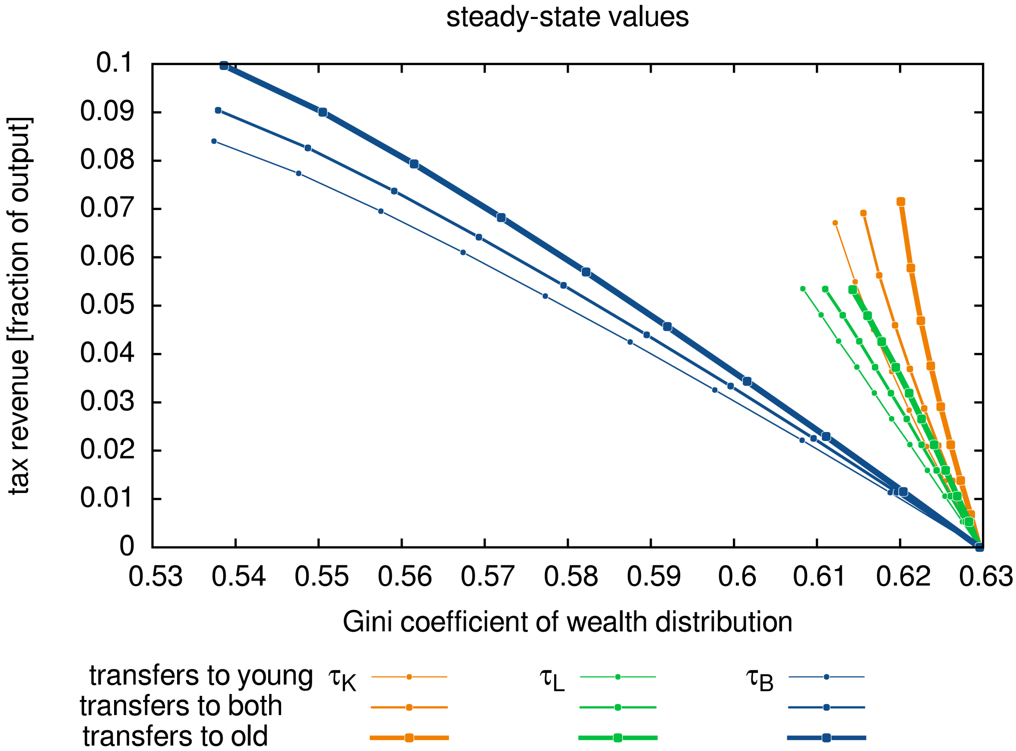

Figure C.2: The revenue raising potential of fiscal policy depends on the recycling scheme used. For all policy instruments, public revenues are higher the higher the share of transfers to the old. However, this effect makes a visible difference only in the case of the bequest tax τ_B. Figure 3 shows how the choice of the transfer scheme affects output.

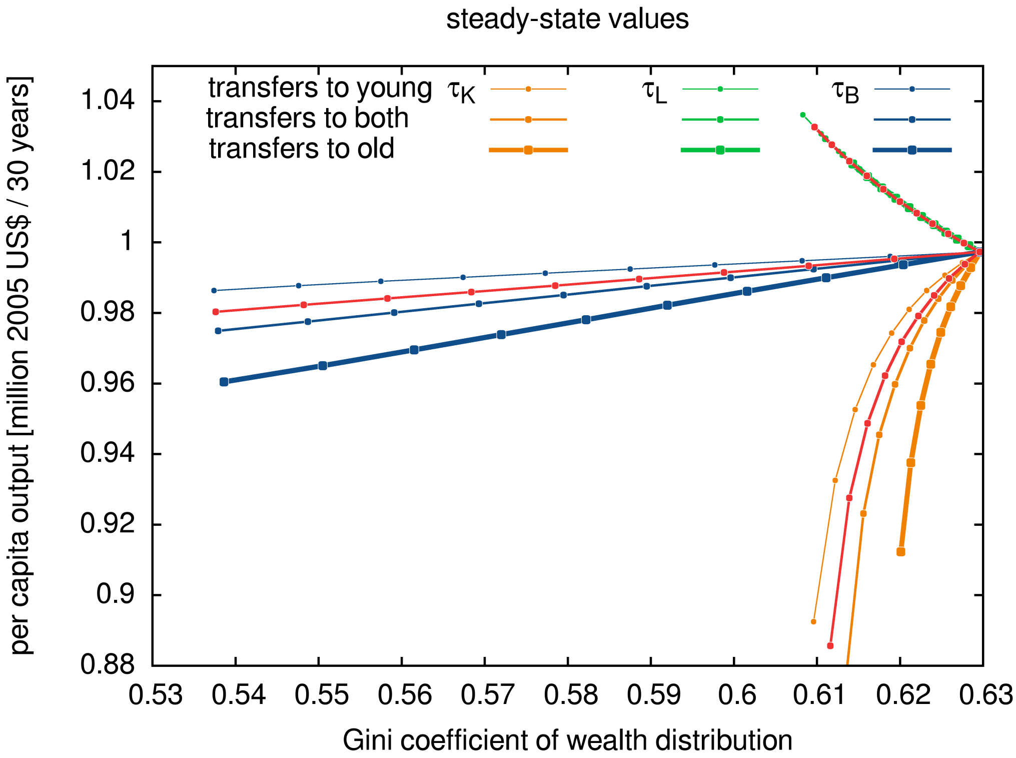

Figure C.3: Impact of different recycling schemes on output and on the wealth distribution (cf. Figure 3). The red lines mark the option space for the case in which public revenues are not redistributed.

	tax rate	tax revenue			output		
		τ_K	τ_L	τ_B	τ_K	τ_L	τ_B
$\epsilon = 0.58$	0.2	11	6	22	990	999	993
	0.5	24	29	52	977	1007	990
	0.7	53	40	71	959	1013	987
$\epsilon = 0.94$	0.2	32	10	19	990	1016	996
	0.5	78	25	39	947	1026	975
	0.7	105	35	44	896	1034	962

Table 4: Steady-state level of tax revenues and output per capita [10^3 2005 US$ / 30 years] for variation of substitution elasticity ϵ under subsequent recalibration of all other parameters.

D. Kaldor-Hicks criterion

Even though we find that recycling all public revenues to the young as lump-sum transfers enhances output and reduced inequality, a Pareto improvement is not possible. However, we find that at least there are cases in which the Kaldor-Hicks criterion is fulfilled. Consider, for instance, the case in which all land rents are skimmed off and redistributed to the young ($\tau_L = 1$, $\delta = 0$) shown in Figure D.4. Absent any additional transfer mechanism between winners and losers, the households belonging to the first old generation always bear the burden, except those in the lowest wealth quintile $i = 1$, whose utility does not change under the 100% land rent tax. Further, not only the first old generation, but in fact all generations belonging to the top wealth quintile $i = 5$ suffer under the tax.

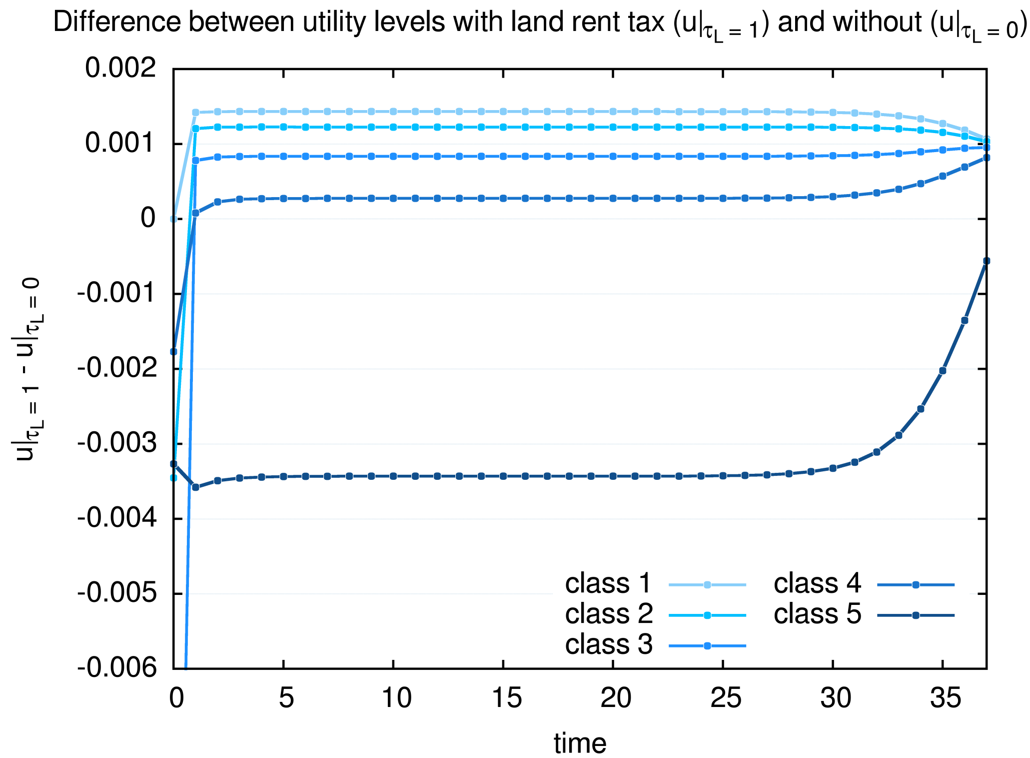

Figure D.4: When land rents are taxed at 100% and recycled as lump-sum transfers to the young, the first old generation and the richest households bear the burden. Their utility under taxation is less than without taxation, i.e., $u|_{\tau_L=1} - u|_{\tau_L=0} < 0$. All other households benefit from the policy.

Now, we introduce a mechanism which allows intertemporal transfers between households. Instead of the lump-sum transfers from public revenues g_t, young and old households may now receive a transfer or have to pay a lump-sum tax X. Their budget equations thus are

$$c^y_{i,t} + s_{i,t} = w_t + b_{i,t}(1 - \tau_B) + X^y_{i,t}$$

$$c^o_{i,t} + b_{i,t} = (1 + R_t(1 - \tau_K))k^s_{i,t} + l_{i,t}(p_t + q_t(1 - \tau_L)) + X^o_{i,t}.$$

Further, we assume that funds can be shifted over time via banking and borrowing at the market interest rate R. Then, for the total volume of the transfers it has to hold that

$$\sum_t \frac{g_t}{\Pi_{s=1}^t(1+R_s)} \geq \frac{1}{N}\sum_{i,t} \frac{X_{i,t}^y + X_{i,t}^o}{\Pi_{s=1}^t(1+R_s)}.$$

Our numerical experiments confirm that there are feasible combinations of $\{X_{i,t}^y, X_{i,t}^o\}_{i=1,\ldots,N,\ t=1,\ldots,T}$ such that the winners of the 100% land rent tax can compensate the losers, i.e., that

$$u_{i,t}|_{\tau_L=1} \geq u_{i,t}|_{\tau_L=0} \quad \forall i,t.$$