The macroeconomic and distributional effects of progressive wealth taxes*

Barış Kaymak†
Université de Montréal and CIREQ

Markus Poschke‡
McGill University and CIREQ

Jul 15, 2016

Preliminary – please do not cite or circulate

Abstract

The recent rise in wealth inequality has triggered a debate on whether policy measures could and should be taken against it. One widely discussed policy, proposed by Thomas Piketty in his book "Capital in the 20th Century", is a progressive tax schedule on wealth. In this paper we evaluate the macroeconomic and distributional consequences of this policy. We find that progressive wealth taxes produce substantial revenue, on the order of that currently raised by the corporate income tax. They also lead to a large reduction in top wealth shares. A comparison of steady states suggests that progressive wealth taxes improve average welfare despite their negative effect on capital accumulation and wages. The interaction with other taxes and differential changes in saving incentives across the wealth distribution are key for this result. In particular, general equilibrium effects imply not only reduced top wealth, but also increased asset accumulation by the bottom 80% of the wealth distribution. The latter is key for higher steady state welfare, but also implies welfare losses along the transition to the new steady state. As a consequence, progressive

*Baris Kaymak acknowledges support from la chaire de la fondation McConnell en études américaines.
†Department of Economics, Université de Montréal, C.P. 6128 succursale Centre-ville, Montréal, QC H3C 3J7, Canada, e-mail: baris.kaymak@umontreal.ca
‡Department of Economics, McGill University, 855 Sherbrooke St West, Montréal, QC, H3A 2T7, Canada, e-mail: markus.poschke@mcgill.ca

welfare taxes look less attractive if positive welfare weight is placed on current generations. Finally, substantial reductions in wealth concentration can also be achieved with more progressive income taxes, which avoid the administrative difficulties associated with wealth taxes.

J.E.L. Codes: E32, J31, J41
Keywords: Tax Progressivity, Wealth Taxes, Income Inequality, Wealth Inequality, Top 1%

1 Introduction

Recent studies documenting a substantial increase in wealth inequality since the early 1970s (notably Saez and Zucman (2014) and Piketty (2014)) have stimulated interest in academic, policy and media circles, launching a debate on whether such an asymmetry in wealth holdings is socially desirable and whether policy could or should combat it.[1] One highly controversial policy proposal comes directly from Thomas Piketty who outlines a global, progressive wealth tax aimed primarily at those at the top of the wealth distribution. While Piketty himself considers his proposal to be "utopian" due to practical difficulties of implementing a globally coordinated wealth tax, progressive wealth taxes are already in place in France, Spain and Switzerland. In Germany, policymakers are currently debating the legislation of a wealth tax, while some other European countries have recently abolished them.[2]

Despite the extensive literature on the taxation of capital income, the implications of a *progressive* tax on capital, particularly for the distributions of income, consumption and welfare, remain largely unknown. These depend crucially on the elasticity of equilibrium prices to policy, the interaction of the wealth tax with the tax and transfer system already

[1]The results on the evolution of wealth inequality in Saez and Zucman (2014) and Piketty (2014) rely largely on administrative tax records. Survey based statistics indicate a similar, but more nuanced picture for US (see Kopczuk (2015) and **?** for a discussion of different methods and data sources).

[2]In France, net assets above 800,000 held by households with net worth of more than 1.3 million are taxed at rates rising from 0.5 to 1.5%. In Spain, net assets above 700,000 are taxed at rates rising from 0.2 to 3.75%, with an exemption of 300,000. Swiss cantons levy progressive wealth taxes with top rates ranging from 0.13 to 0.94%, typically with an exemption of CHF100,000.

in place and the joint distribution of income and wealth as well as the factor composition of income at different points along the wealth distribution.

In this paper, we study the short and long run effects of introducing a progressive wealth tax in a quantitative heterogeneous-agent model designed to reproduce the distributions of wealth and income in the United States in 2010. We conduct our analysis using a dynamic model of consumption and savings with uninsurable idiosyncratic income risk and endogenous labor supply building on Aiyagari (1994); Bewley (1986); Huggett (1993). We make two modifications to the standard model in the spirit of Castaneda, Diaz-Gimenez, and Rios-Rull (2003). First, we combine dynastic and life-cycle elements of decision-making at the household level: households in the model go through two stages of the life-cycle: the work stage, where they face idiosyncratic income risk, and the retirement stage, where they live off their pension income and private wealth. Upon death, they are replaced by their descendents, towards whom they are perfectly altruistic. Second, we introduce a persistent but rarely visited state, where an individual is exceptionally productive. These modifications allows us to generate realistic distributions of income and wealth by combining three fundamental motives for wealth accumulation: a precautionary savings motive to insure against life-cycle income risk, a consumption smoothing motive to save for retirement, and a bequest motive to endow estates for their offsprings. The relative strength of each motive depends on a household's productivity and wealth. Importantly, the model generates not only realistic marginal distributions of income and wealth, but also a correlation between these variables that is close to that observed in the data.

To this setting, we introduce a progressive income tax system, estate taxation, corporate income taxation and a tax-financed pay-as-you-go social security system. The presence of a social security system helps account for the bottom-tail of the wealth distribution. The progressive income tax-system is crucial for translating the pre-tax earnings distribution to consumption and wealth inequality. The estate and corporate income taxes are important for our purpose as they also affect incentives to save. We then calibrate model parameters to replicate the income and wealth distributions in 2010, while matching life-cycle and intergenerational transitions in income.

In this environment, we introduce progressive wealth taxes as proposed by Piketty (2014). Piketty proposes three scenarios: *a)* a tax rate of 1% on wealth between 1 and 5 million euros (between $1.325 and $6.625 million in 2010) and a rate of 2% above 5 million euros, *b)* in addition, a 5% tax rate on an additional top bracket starting at 1 billion euros

($1.325 bn), or *c)* an additional 0.1% tax on all wealth below 200,000 euros ($265,000) and a tax of 0.5% on wealth between 200,000 and 1 million euros. In a technical appendix to his book, Piketty also proposes a scheme where the 5% rate already kicks in at 20 million euros, and a 10% rate at 100 million euros.[3] We study precisely this scheme because of the attention it has received. While other tax schemes might be considered, the strong progressivity built into Piketty's scheme makes it a good example of a progressive wealth tax.[4] We also compare our results to Piketty's simulations of the effects of the same tax, highlighting the importance of using a model in evaluating the proposal. (Another evaluation is Schuyler (2014).) While Piketty suggests using revenue from the progressive wealth tax to reduce other wealth taxes, i.e. he essentially proposes integrating wealth taxes and making them progressive, we assume that they are used to reduce income taxes. (Alternatively, one could assume that revenues are redistributed lump sum.)

Theory would lead one to expect reduced saving and capital accumulation in response to a wealth tax, especially at the top of the wealth distribution, where tax rates are highest. This is exactly what the model predicts, with a reduction of the aggregate capital stock of 13%. In general equilibrium, this implies that the wage rate declines by 4.6%, and the interest rate increases by 0.9 percentage points. Importantly, however, the wealth tax revenue raised, which amounts to 2.4% of GDP, allows reducing the average income tax rate by 3.5 percentage points. As a consequence, the average after-tax wage hardly changes. The same is true for aggregate labor supply. Revenue from the wealth tax is substantial, and roughly similar to that currently raised from the corporate income tax.

While the predictions of our model for potential wealth tax revenue are close to those of Piketty (2014, Chapter 15 and technical appendix), our model also allows us to evaluate distributional and welfare implications of a progressive wealth tax. This is the first study to be able to do so.[5] Distributional implications are strong: progressive wealth taxes imply a reduction of the top 1% (10%) wealth share of 11 (10) percentage points. The bottom 80% wealth share increases substantially in response to the higher interest rate.

[3]For reference, for a Pareto tail index of the distribution of private wealth of 1.4, in 2010, wealth of $1.325 million roughly corresponds to the 4th percentile of the wealth distribution, and $6.625 (26.5) [132.5] million to the 0.4th (0.06th) [0.007th] percentile.

[4]To stress the effect of progressivity of the scheme, we compare results to those with a flat tax raising the same amount of revenue.

[5]Revenue estimates by Bach and Thiemann (2016) for a potential wealth tax in Germany are lower, due to lower simulated tax rates and more exemptions, e.g. for business assets. Their estimates for the change in the wealth Gini are similar to ours. Like Piketty's simulations, this study abstracts from general equilibrium effects.

The general equilibrium price adjustments imply that in contrast to the changes in the wealth distribution, the distribution of both pre- and after-tax income hardly changes.

Aggregate welfare in the steady state with progressive wealth taxes slightly exceeds that in the benchmark. The same is true for expected welfare of a new-born worker. This difference arises from the balance of two effects. First, fixing the benchmark distribution of household wealth and productivity, welfare is lower with progressive wealth taxes for 80% of households. This is because they consume less and save more, in response to the higher interest rate, and because they work slightly more. This first effect is dominated by the long-run consequences of higher savings: The bottom 80% of the wealth distribution hold more wealth in the steady state with wealth taxes. The second effect dominates, implying that overall, average welfare is higher with progressive wealth taxes.

This result already suggests that long-run and short-run consequences of introducing progressive wealth taxes may differ. Results from computing the transition of the model economy to the steady state induced by wealth taxes show that this is indeed the case. Because accumulating wealth requires consuming less, in particular in the early stages of the transition, welfare directly after introduction of progressive wealth taxes is actually lower than in the benchmark economy for the large fraction of households who increase their savings. It takes them a long time to reach the final, higher steady-state welfare. Therefore, a reform introducing progressive wealth taxes may not be desirable if policy makers put a sufficiently large welfare weight on initial generations.

It is clear from this discussion that the welfare effects of wealth taxes in this framework depend crucially on their distributional implications, and on how they affect saving incentives in different parts of the wealth distribution differently. This is very different from the factors that are typically stressed in the literature on capital income taxation. There, the spotlight is put on the rate at which capital income taxes crowd out capital accumulation. (See Chamley (1986) and Judd (1985), but also Conesa, Kitao, and Krueger (2009) and Straub and Werning (2014).) Existing incomplete-markets analyses of optimal capital taxation typically focus on the motive to curb overaccumulation of capital arising from precautionary saving (Chamley, 2001; Aiyagari, 1995). In the setting with realistic wealth heterogeneity analyzed here, the key factor instead are differential saving incentives across the wealth distribution. In particular, welfare changes hinge not only on how wealth taxes discourage capital accumulation at the top, but also on how they promote saving throughout the distribution via their effects on prices in general equilibrium. This in turn is key to understand the difference between short-run and long-run effects.

The effects of progressive wealth taxes also contrast with those of flat wealth taxes. First, our results show that flat wealth taxes do not reduce wealth inequality, as they affect saving incentives similarly for all wealth groups. They do however reduce capital, output, consumption and pre-tax wages, albeit slightly less than progressive wealth taxes. They also raise income inequality, as a consequences of the change in wealth inequality and equilibrium prices. As a result, aggregate welfare declines slightly compared to the benchmark.

An interesting next step (in progress) constitutes in comparing the effect of progressive wealth taxes to other schemes besides flat wealth and capital income taxes, like e.g. progressive taxes on capital income or consumption. The former are conceptually closely related to progressive wealth taxes. The latter have been proposed as a superior alternative in the debate about Piketty's proposal. (See Jokisch and Kotlikoff (2007) for an analysis in a life cycle model.)

Related literature. Relative to the vast literature on (optimal) capital income taxation, the literature on wealth taxes is much thinner. For instance, while Panousi and Reis (2015) and Guvenen et al. (2016) study optimal capital income and wealth taxes in a heterogeneous-agent economy with idiosyncratic investment risk, both papers only consider linear taxes. Kindermann and Krueger (2014), Badel and Huggett (2014) and Guner, Lopez Daneri, and Ventura (2014) study the optimal taxation of the top 1% income earners, and thus progressive income taxes, but focus on labor income. Kaymak and Poschke (2016) investigate the forces driving the increase in top wealth shares in the US since 1960.

A small set of papers analyzes optimal progressive taxes on capital income or wealth. Kocherlakota (2005) studies optimal wealth and labor taxation in a Mirrleesian setup. He finds that in this setting, the expected wealth tax should be zero and wealth taxes should be income-contingent. Shourideh (2012) studies the optimal taxation of capital income in a model with capital income risk. In numerical simulations, he finds optimal capital taxes to be progressive for reasons of redistribution. Finally, Saez (2013) shows that for an exogenous distribution of initial wealth, optimal capital income taxes may be progressive. Not only do none of these papers consider the wealth tax schedule analyzed here, they also all focus on different economic effects.

This paper is organized as follows. In the next Section, we present the model used for the quantitative analysis. Section 3 describes its calibration, and Section 4 the quantitative fit of the model. Sections 5 and 6 analyze the effects of introducing progressive wealth taxes in the model in steady state and along the transition to the new steady state, respectively. Section 7 concludes and compares our results to the few other existing simulations of progressive wealth taxes.

2 Model

The model economy is a modified version of the neoclassical dynamic stochastic general equilibrium model with uninsurable idiosyncratic income risk (Aiyagari, 1994; Bewley, 1986; Huggett, 1993). We combine the standard model with a demographic structure that closely resembles Castaneda, Diaz-Gimenez, and Rios-Rull (2003), and a detailed, non-linear tax system.

The economy consists of a continuum of heterogeneous households, a representative firm, and a government. Households form dynasties: each one is replaced by a descendant upon death. New entrants to the economy inherit an estate from their parents and start their working life. While working, they face a constant probability of retirement μ_r. Once retired, they still make consumption and savings choices, but cannot work anymore. Retirees die with a constant probability μ_d. Upon death, they are replaced by a descendant who inherits their estate. Let the proportion of retirees in the economy be M_1, and let $\mathcal{R}$ be one for retirees and zero for workers.

At any point in time, a continuum of agents of measure 1 is alive, each endowed with individual-specific capital k and labor skill z. With these endowments, agents can generate a pre-tax income of $y = zwh + rk$, where w is the market wage per skill unit, $h \in [0, 1]$ is hours worked and r is the interest rate net of depreciation. We assume that the labor productivity falls to zero when workers retire. As a result, retirees do not work and receive a fixed social security benefit $\omega(\mathcal{R})$.

Private income from labor and savings, corporate income and estates are subject to a detailed tax system, outlined below. The government uses tax revenue to finance an exogenous stream of expenditures G. Let the disposable income of an agent net of all types of income taxes be y^d. This depends both on total income and on capital holdings, due to the different tax components. Agents can allocate their resources between consumption and investment in capital. This capital stock constitutes savings for an individual, and becomes the estate that is passed on to a descendant in case of death. To rule out negative bequests, agents cannot borrow. Let x denote an agent's beginning-of-life capital holdings, before paying potential estate taxes due on an inheritance, and k the capital holdings after paying any estate tax. Capital depreciates at a rate δ between periods.

A worker's labor skill z follows a first-order Markov process $F_0(z'|z)$. A descendant enters the economy with her/his own labor skill, which is drawn from a *cdf* $F_1(z'|z)$. The distribution of skill upon labor market entry thus depends on parents' pre-retirement skill.

Agents value consumption, and they dislike work. They care about their welfare as well as about their offspring's, discounting future utility using a constant discount factor $\beta \in (0,1)$. The problem of an agent then is to choose labor hours, consumption and capital investment to maximize expected discounted utility of the entire dynasty. In doing so, agents take the wage rate, the interest rate and the aggregate distribution of agents over wealth and productivity, denoted by Γ, as given. Let Γ_0 be the distribution for workers, Γ_1 that for retirees, and let $\Gamma' = H(\Gamma)$ describe the evolution of the distribution over time. Also, let $\Gamma_{01}(x,z)$ denote the end-of-period capital distribution for retirees. The Bellman equation for a consumer's problem then is

$$V(k,z,\mathcal{R};\Gamma) = \max_{c,x,k'\geq 0,\ h\in[0,1]} \left\{ \frac{c^{1-\sigma}}{1-\sigma} - \theta \frac{h^{1+\epsilon}}{1+\epsilon} + \beta \mathbb{E}[V(k',z',\mathcal{R}';\Gamma')|z] \right\} \tag{1}$$

subject to

$$\begin{aligned} c + x &= y^d(wzh, rk, \omega(\mathcal{R})) + k, \\ k' &= x - E(x,\mathcal{R},\mathcal{R}'), \\ \Gamma' &= H(\Gamma), \end{aligned}$$

where the expectation is taken over retirement and survival risk and skill transition risk, for both survivors and the newborn. $E(x,\mathcal{R},\mathcal{R}')$ denotes the estate tax liability, where x is the estate. The estate tax is zero except for entrants, i.e. unless $\mathcal{R} = 1$ and $\mathcal{R}' = 0$. For retirees, the labor supply choice is fixed at zero. Only retirees receive social security benefits $\omega(z)$.

The representative firm produces output Y using aggregate capital K and effective labor N. Its production technology takes the Cobb-Douglas form $F(K,N) = AK^{\alpha}N^{1-\alpha}$. Factor markets are competitive, and firms are profit maximizers.

A *competitive equilibrium* of the model economy consists of a value function, $V(k,z,\mathcal{R};\Gamma)$, policy functions for factor supplies, $k'(k,z,\mathcal{R};\Gamma)$ and $h(k,z,\mathcal{R};\Gamma)$, a wage rate, $w(\Gamma)$, an interest rate $r(\Gamma)$, and an evolution function $H(\Gamma)$ such that:

1. Given $w(\Gamma)$, $r(\Gamma)$ and $H(\Gamma)$, $V(k, z, \mathcal{R}; \Gamma)$ solves the consumer's problem defined by (1) with the associated factor supplies $k'(k, z, \mathcal{R}; \Gamma)$ and $h(k, z, \mathcal{R}; \Gamma)$.

2. Factor prices are given by the following inverse demand equations:

$$\begin{aligned} r(\Gamma) &= \alpha A(K/N)^{\alpha-1} - \delta \\ w(\Gamma) &= (1-\alpha)A(K/N)^{1-\alpha} \end{aligned}$$

3. Markets clear:

$$K' = \int k'(k, z, \mathcal{R}; \Gamma) d\Gamma(k, z) \quad \text{and} \quad N = \int z h(k, z, \mathcal{R}; \Gamma) d\Gamma(k, z).$$

4. $H(\Gamma)$ is consistent with $F_0(z'|z)$, $F_1(z'|z)$, μ_r, μ_d and the savings policy $k'(k, z, \mathcal{R}; \Gamma)$.

5. The government budget is balanced:

$$G + M_1 \int \omega(\mathcal{R}) d\Gamma_1(k, z) = \int [y - y^d(y)] d\Gamma(k, z) + \mu_1 M_1 \int E(x, 1, 0) d\Gamma_{01}(x, z).$$

A *steady-state* of the economy is a competitive equilibrium where the distribution of agents is stationary, i.e. $\Gamma^{ss} = H(\Gamma^{ss})$.

3 Functional Forms and Calibration

The economy is calibrated in two steps. First, we choose a set of parameters based on information that is exogenous to the model. Then, we calibrate the remaining parameters so that the model economy is consistent with a set of relevant aggregate statistics of the U.S. economy and the empirical distributions of income and wealth in 2010.

The calibration of the 2010 economy is broadly consistent with the standard for quantitative models with idiosyncratic labor income risk. However, we make two modifications in the spirit of Castaneda, Diaz-Gimenez, and Rios-Rull (2003) so that the model economy features realistic income and wealth distributions with high concentrations at the top. First, we augment the standard stochastic processes for labor productivity estimated from survey data by allowing households a small chance of reaching an extraordinarily high labor productivity level. Second, we introduce a stochastic life cycle, where households retire and die probabilistically, and allow for a correlation in labor productivity across generations. Note that the current calibration is still preliminary. It does, however, do justice to the high concentration of income and wealth observed in the data.

3.1 Technology

The level of production technology, A, is normalized to 1. Capital's share in income, α, is set to 0.36. Given the calibration target for the annual interest rate of 2.8%, the annual depreciation rate is set to 7.9%, which ensures that the ratio of capital stock to aggregate income in 2010 is 3.

3.2 Demographics and Income Process

The demographics and the income process are jointly governed by the transition matrices described below:

$$\Pi = \left[\begin{array}{c|cc} & z_W & z_R \\ \hline z_W & \Pi_{WW} & \Pi_{WR} \\ z_R & \Pi_{RW} & \Pi_{RR} \end{array}\right]$$

where z_W is a vector of labor productivity levels for a working household. The idiosyncratic labor income risk during employment is governed by the matrix Π_{WW}. The transitions from work to retirement is governed by Π_{WR}. We assume that, each period, workers face a fixed probability of retirement, μ_r, that is independent of their labor productivity. As a result Π_{WR} is a diagonal matrix with μ_r along the diagonal. We set $\mu_R = 1/45$ to obtain an average career length of 45 years. Once retired, households face a constant death probability μ_d. Consequently, Π_{RR} is a diagonal matrix with $1 - \mu_d$ along the diagonal. We set $\mu_d = 1/15$ to obtain an average retirement duration of 15 years. When a household dies, it is replaced by a working age descendant. The intergenerational transition in labor productivity is governed by Π_{RW}.

We assume that the vector $z_W = [z_j]$ contains 6 distinct values in increasing order of which $\{z_1, .., z_4\}$ are ordinary states and $\{z_5, z_6\}$ are extraordinary states reserved for exceptionally high earnings levels that are commonly censored in the survey data. The ordinary levels of productivity consist in combinations of two components: a permanent component, $f \in \{f_H, f_L\}$, that is fixed over a household's lifespan, and a random component, $a \in \{a_L, a_H\}$. Let $F = [F_{ij}]$ and $A = [A_{ij}]$ with $i, j \in \{L, H\}$ be 2-by-2 transition matrices associated with the two components f and a. With this formulation, idiosyncratic fluctuations in labor income risk along the life cycle are captured by A, and those across generations by F. The following matrices summarize the stochastic labor productivity process over the life cycle and across generations.

$$\Pi_{WW} = \left(\begin{array}{c|cccccc} & f_L + a_L & f_L + a_H & f_H + a_L & f_H + a_H & z_5 & z_6 \\ \hline f_L + a_L & A_{11} & A_{12} & 0 & 0 & \lambda_{in} & 0 \\ f_L + a_H & A_{21} & A_{22} & 0 & 0 & \lambda_{in} & 0 \\ f_H + a_L & 0 & 0 & A_{11} & A_{12} & \lambda_{in} & 0 \\ f_H + a_H & 0 & 0 & A_{21} & A_{22} & \lambda_{in} & 0 \\ z_{awe_l} & \lambda_{out} & \lambda_{out} & \lambda_{out} & \lambda_{out} & \lambda_{ll} & \lambda_{lh} \\ z_{awe_h} & 0 & 0 & 0 & 0 & \lambda_{hl} & \lambda_{hh} \end{array} \right)$$

$$\Pi_{RW} = \left(\begin{array}{c|cccccc} & f_L + a_L & f_L + a_H & f_H + a_L & f_H + a_H & z_5 & z_6 \\ \hline f_L + a_L & F_{11} & 0 & F_{12} & 0 & 0 & 0 \\ f_L + a_H & F_{11} & 0 & F_{12} & 0 & 0 & 0 \\ f_H + a_L & F_{21} & 0 & F_{22} & 0 & 0 & 0 \\ f_H + a_H & F_{21} & 0 & F_{22} & 0 & 0 & 0 \\ z_{awe_l} & F_{21} & 0 & F_{22} & 0 & 0 & 0 \\ z_{awe_h} & F_{21} & 0 & F_{22} & 0 & 0 & 0 \end{array} \right)$$

The following additional assumptions are explicit in the formulation of the matrices. The probability of reaching an extraordinary status within lifetime, λ_{in}, is independent of one's current state. Likewise, if a household loses their extraordinary status, then it is equally likely to transition to any ordinary state.[6] The descendant households start their career at a_L. This helps generate wage growth over the life cycle. It is also consistent with a higher variance of wages for older workers. The probability having a low or high permanent component for a descendant of a household at the extraordinary state is the same as of a household with a high permanent productivity component. The chances that the descendant of an extraordinarily productive household will also be as productive is zero. Relaxing these restrictions leads to negligible improvements in the performance of the model.

Our working assumption is that the values for ordinary states and the transitions

[6]The formulation of the transition matrix allows for the possibility of transitioning between different values of the permanent component f by passing through an extraordinary state. However, given the calibrated values for λ_{in} and λ_{out} below, the probability of such an event is extremely small.

within are directly observed in the data, whereas the transitions to, from and within extraordinary states are not. We jointly calibrate the levels of ordinary states, $\{z_1, .., z_4\}$, and the elements of the transition matrices A and F in order to match the average wage growth of 0.305 log-points observed in the data, the annual autocorrelation of 0.985, as estimated by Krueger and Ludwig (2013), the variance of earnings for working age households, which is reported as 0.75 by Heathcote, Perri, and Violante (2010) and the intergenerational elasticity of wages of 0.30 as reported by Solon (1999). This leaves the transitional probabilities $(\lambda_{in}, \lambda_{out}, \lambda_{ll}, \lambda_{lh}, \lambda_{hl}, \lambda_{hh})$ and the extraordinary productivity levels z_5, z_6. We choose the values for these parameters to replicate the observed distributions of income and wealth in 2010. In particular we target the top 0.5 and 1 percent concentration ratios and the Gini coefficients of inequality for income and wealth.

3.3 Tax System

The tax system consists of personal income taxes levied on capital and labor earnings, corporate taxes, and taxes on estate income. The tax receipts are used to support exogenous government expenditures and transfers to households.

Corporate taxes are modeled as a flat rate, τ_c, levied on a portion of capital earnings before households receive their income.[7] We set $\tau_c = 23.6\%$, which is the average marginal tax rate on corporate profits in 2010 as reported by Gravelle (2014) based on tax records. To reflect the fact that for most households, positive net worth takes the form of real estate and thus is not subject to corporate income taxes, we assume that corporate taxes only apply to capital income above a threshold d_c.[8] We then choose d_c such that the share of corporate tax revenue in GDP is 1.9%, as in the period 2004-2010.

Personal income taxes are applied to earnings, non-corporate capital income and pension income, if any. Taxable income for income tax purposes is given by:

$$y_f = zwh + \min\{rk, d_c\} + \omega(\mathcal{R}). \tag{2}$$

Total disposable income is obtained after applying corporate and personal income taxes and adding lump-sum transfers from the government:

[7] As a result, corporate income taxes reduce the tax base for personal income tax.

[8] Only about 20% of U.S. households hold stocks or mutual funds directly (Heaton and Lucas 2000, Bover 2010).

$$y^d = \max\{\lambda y_f^{1-\tau}, (1-\tau_{max})y_f\} + (1-\tau_c)\max(rk - d_c, 0) + Tr. \quad (3)$$

The first term above represents our formulation of the current U.S. income tax system, which can be approximated by a log-linear form for income levels outside the top of the income distribution. The power parameter $\tau \leq 1$ controls the degree of progressivity of the tax system, while λ adjusts to meet the government's budget requirement. $\tau = 0$ implies a proportional (or flat) tax system. When $\tau = 1$, all income is pooled, and redistributed equally among agents. For values of τ between zero and one, the tax system is progressive.[9] See Guner, Kaygusuz, and Ventura (2014), Heathcote, Storesletten, and Violante (2014) and Bakış, Kaymak, and Poschke (2015) for evidence on the fit of this function.

One advantage of this formulation for the income tax system is that it also allows for negative taxes. Income transfers are, however, non-monotonic in income. When taxes are progressive, transfers are first increasing, and then decreasing in income. This feature allows addressing features of the real tax system like the earned income tax credit and welfare-to-work programs, which imply transfers that vary with income.

When disposable income is log-linear in pre-tax income, the marginal tax rate increases monotonically with income, converging to 100% at the limit. This is undesirable since an increase in top income levels is mechanically accompanied by higher marginal tax rates. The second term in the maximum operator avoids this feature by imposing a cap on the top marginal tax rate, denoted by τ_{max}. The top marginal tax rate in 2010 is set to 35%, as reported by the IRS. The progressivity of the general income tax system, τ is not directly available. Here, we set it to match income taxes paid by the top 1% income earners relative to their income, relative to the same statistic for the bottom 99% income earners. This results in a value of τ of 0.08.

Finally, estates are subject to tax when they are transferred to the next generation. The estate tax code in the U.S. consists of a deductible and a progressive schedule applied to the remaining portion of the estate. We represent the marginal estate tax schedule by the step function depicted in Figure **??**. We do so using statutory estate tax rates and the corresponding brackets reported by the IRS.

The government uses the tax revenue to finance exogenous expenditures and transfers. The expenditures are set at 10.8% of GDP to yield a sum of expenditure and transfers

[9] The average income tax rate is $1 - \lambda y^{-\tau}$, which increases in y if $\tau > 0$.

of 17% of GDP, as observed in the data. In addition, the government makes lump-sum transfers to households. In the data, transfers to persons in 2010 represent 10% of GDP, of which 8% is destined to the elderly in the form of pension and medicare payments and 2% is destined to the general public in the form of disability benefits, veterans benefits etc. We set the transfers in the model T_E and T_R accordingly, to match receipts per person. In a last step, we choose λ in the personal income tax function to balance the government's budget.

3.4 Preferences

Preferences are described by a discount rate, β, the elasticity of intertemporal substitution, σ, the Frisch elasticity of labor supply, ϵ, and the disutility of work, θ. We choose β such that the equilibrium interest rate is 2.8%. We set $\epsilon = 1.67$, which implies a Frisch elasticity of 0.6. Blundell, Pistaferri, and Saporta-Eksten (2012) report an estimate of 0.4 for males and 0.8 for females. Thus a value of 0.6 for a model of households seems broadly plausible. We choose θ so that at the equilibrium an average household allocates 35% of their time endowment to work.

The intertemporal elasticity of substitution is an important element of our analysis since a higher elasticity lead to a stronger savings response to tax cuts. We report our results for $\sigma = 1.1$, which implies an EIS of 0.9. As most estimates of the EIS are closer to zero, we consider our choice to be an upper bound. Actual effect of tax cuts on economic inequality is therefore likely to be smaller than our benchmark results.

Table 1 summarizes the calibration of the model.

4 The benchmark economy

In this section we overview the characteristics of economy implied by our calibration of the model and compare them with the available statistics in the data. The elements of the matrix within ordinary labor productivity states were already calibrated to match panel data on wages. Therefore we focus our discussion on the implied transition probabilities for the extraordinary states. The probability of reaching an extraordinary state at any given year is 0.2 percent, and the probability of going back to an ordinary state is 13.6%.[10] These figures imply a considerable degree of persistence of having a high

[10]The full set of calibrated values for the transition matrices are reported in the appendix.

Table 1: Calibration of the model parameters

Parameter	Value	Data Target and Value	
		Preset Parameters	
σ	1.1	Risk Aversion	
α	0.36	Capital Income Share	
δ	0.079	$K/Y = 3.0$	
μ_r	0.022	Average Career Length of 45 yrs.	
μ_d	0.067	Average Retirement Length of 15 yrs.	
		Taxes	
τ_l	0.08	Average income tax burden on top 1%	
τ_c	0.236	Marginal Corporate Tax Rate, Gravelle (2010)	
τ_e		Actual Estate Tax Schedule	
γ	0.108	$G/Y = 0.17$	
		Productivity Process	
ρ_{lc}	0.985	Kindermann and Krueger (2014)	
ρ_{ig}	0.30	Solon (1992)	
σ_a	0.5×0.38	household earnings variance	0.71
σ_f	0.5×0.62	share of fixed effects	0.62
		Jointly Calibrated Parameters	
β	0.958	Interest Rate	0.028
θ	12	mean hours	0.35
ϵ	1.67	Frisch elasticity	0.6
ψ^*	0.215	(Pension+Medicare)/GDP	8%
d_c/r	$0.47 \times K$	Corporate tax revenue/GDP	1.9%

Table 2: Distribution of Income and Wealth in 1960

	Top Percentile							
	0.5%	1%	5%	10%	20%	40%	60%	Gini
Wealth Share (Data)	**0.21**	**0.28**	n/a	0.71	0.81	0.95	1.00	**0.80**
Wealth Share (Model)	**0.22**	**0.26**	0.46	0.62	0.79	0.91	0.99	**0.75**
Income Share (Data)	**0.07**	**0.10**	0.23	0.33	0.49	0.73	0.89	**0.34**
Income Share (Model)	**0.09**	**0.11**	0.24	0.41	0.54	0.76	0.87	**0.33**
Earnings Share (Data)	0.05	0.07	0.20	0.33				0.34
Earnings Share (Model)	0.09	0.10	0.22	0.35	0.50	0.67	0.87	0.33

Note.– The data values are taken from Saez and Zucman (2014) and Keister and Moller (2000) for the wealth distribution, and from Piketty and Saez (2003) for the income and earnings shares. Wealth shares are for a wealth ordering of the population, and income and earnings shares for an ordering by income. The income and earnings Ginis are from Heathcote, Perri, and Violante (2010) and refer to 1967, the earliest year for which they report results. The income Gini in both model and data refers to working-age households. See text for details.

earner status. There is, however, little information on the transitions to, from and within extraordinary states in the data. Using micro-level data from the Social Security Administration, Kopczuk, Saez, and Song (2010) estimate the probability of staying in the top 1% of earners from one year to the next to be around 75%. The probability is fairly stable over the years fluctuating between 70 to 80%. The corresponding probability implied by our calibration is 74%.

The extraordinary states are essential to the model's ability to generate a realistic wealth distribution. At these states (z_5 and z_6), which represent the most productive 1.3% of the labor force combined, labor productivity is 12 times the average. The top state z_6 alone corresponds to 0.08% of the workforce, with a productivity level that is 115 times the average. When households reach these states, they also work about 35% longer hours than an average household to take advantage of the higher wages and build up a substantial amount of wealth against the risk of losing their highly productive status either by retirement or by returning to an ordinary state. The resulting wealth distribution is very highly concentrated as observed in the data.

Table 3 shows the distributions of total income, wealth and labor income for the model economy. The calibration targets are reported in bold. The data on the wealth distribution comes from two different sources. Top 0.5, 1 and 10 percent concentration ratios are taken

Table 3: Income and Wealth Inequality in 2010

	Top Percentile							
	0.5%	1%	5%	10%	20%	40%	60%	Gini
Wealth Share (Data)	0.31	0.40	n/a	0.74	0.83	0.95	0.99	0.82
Wealth Share (Model)	0.43	0.52	n/a	0.86	0.98	0.99	1.00	0.92
Income Share (Data)	0.16	0.20	0.35	0.46	0.62	0.82	0.94	0.43
Income Share (Model)	0.15	0.17	0.35	0.49	0.53	0.75	0.88	0.53
Earnings Share (Data)	0.12	0.16	0.33	0.47				0.42
Earnings Share (Model)	0.17	0.21	0.34	0.47	0.57	0.72	0.90	0.42

from Saez and Zucman (2014), who infer the wealth distribution from the reported capital income in tax records and observed returns by asset type in the US economy. They do not report distributional measures for lower wealth levels. The remaining shares and the Gini coefficient are therefore taken from Diaz-Gimenez, Glover, and Ríos-Rull (2011) and are based on the 2007 Survey Consumer Finances (SCF). The model closely approximates the distributions of income and wealth. (The current, preliminary calibration overstates wealth inequality. We are in the process of fixing this.) While the earnings distribution implied by the model is slightly more concentrated at the top than in the data, the Gini coefficient of earnings in the model is very close to that reported by Heathcote, Perri, and Violante (2010). The main reason for this discrepancy is that the data figures come from Piketty and Saez (2003), who report concentration ratios for wage income shares only. The relevant statistic that corresponds to the model is total labor income, including a portion of entrepreneurial income, which is excluded by Piketty and Saez (2003). Since the share of entrepreneurial income in total income is substantial for the top income/earnings groups, excluding it biases the concentration ratios downward.[11] In line with this, the model fits the share of labor income in the top 1% incomes almost exactly, at 80% versus 81% in the data (Piketty and Saez, 2003, updated data tables), and only slightly understates them for lower groups (e.g. 84% in the model versus 90% in the data for the top 10%). The correlation of income and wealth in the model economy is 0.4, slightly below that reported by Diaz-Gimenez, Glover, and Ríos-Rull (2011) from the 2007 SCF.

[11] Income from entrepreneurial activities constitutes 30% of total income for the top 1% of incomes, and 17% of total income for the top 10% in 1960.

Table 4: Average Tax Rates by Income Group in the benchmark economy

	Corporate Tax			Estate Tax			Income Tax		
	1%	99%	R/Y	1%	99%	R/Y	1%	99%	R/Y
Data	5.1	1.9	1.9	2.2	0	0.3	25.8	19.4	23
Model	4.6	1.7	1.9	2.5	0.3	0.7	27.6	22.7	24

Note.– R/Y stands for revenue as a fraction of GDP. The data values come from NIPA and from Joulfaian (2013). The data values for the top 1% and 99% are taken from Piketty and Saez (2007).

A critical element of the analysis is the distribution of the tax burden across income groups. Since our modeling of the corporate and estate tax systems does not explicitly target income groups, the model's ability to shed light on the distributional consequences of changing tax schedules depends on how well it captures the tax liabilities of different income groups in the benchmark economy. In their survey of tax records, Piketty and Saez (2007) report the average tax rates for different tax categories for top income groups. In Table 4, we compare the reported values with the model-implied rates for the top 1% and the bottom 99% of the income distribution. The model matches the aggregate revenue from corporate taxes by design. At the same time, it reflects that the top 1% pay much more corporate taxes as a fraction of their income, given their higher capital income share. Aggregate estate tax revenue in the model somewhat overstates that in the data. The model matches the fact that the 99% pay essentially no estate taxes. Finally, the progressivity of the personal income tax system chosen in our preliminary calibration reflects the distribution of the income tax burden in the data fairly accurately.

Overall, the calibration of the parameters seems reasonable, as the model does a good job of capturing the salient features of the US economy. In particular, the distributions of income, wealth and the tax burden among households is consistent with the empirical facts. We find this encouraging as it indicates that the model provides an appropriate framework to study the macroeconomic and distributional implications of introducing wealth taxes, which we turn to next.

5 The effect of progressive wealth taxes: stationary equilibria

In this section, we compare the benchmark steady state to equilibria brought about by introducing three different wealth tax policies: the benchmark policy proposed by Piketty and described in the introduction, the broader policy which also taxes low wealth levels, albeit at a low rate, and a flat wealth tax, without any exemption, that raises the same amount of revenue in steady state as the basic proposal.[12] We first discuss the steady states induced by these policies and compare them to the benchmark. In the next section, we analyze the transition to the steady state for the basic wealth tax scenario.

Recall here that the basic proposal features a tax rate of 1% on wealth between 1 and 5 million Euros, and a tax rate of 2% on wealth above 5 million Euros. These thresholds correspond approximately to the 92nd and 99th percentiles of the wealth distribution in the benchmark economy and similar percentiles in the SCF (see e.g. Diaz-Gimenez, Glover, and Ríos-Rull, 2011, Table 1).[13]

5.1 Aggregate implications of progressive wealth taxes

Table 5 shows key aggregate variables for the benchmark economy and for the three wealth tax scenarios. These outcomes are similar in all three scenarios with the tax. First, a wealth tax discourages saving, and therefore implies that the capital stock is noticeably lower in steady states with wealth taxes. The lower capital stock implies substantially lower wages and a higher interest rate. In response to lower wages, aggregate labor supply is slightly lower. Lower capital and labor supply imply substantially reduced output. For aggregate consumption, the effect of lower output dominates that of lower capital. Aggregate consumption thus declines by 1.5-3%.

One important further implication of the introduction of wealth taxes is a shift in the composition of the tax system. Table 6 shows the composition of tax revenue in detail. Note that we are assuming that government spending as a fraction of output is constant. Transfers are also closely tied to output, so that aggregate spending and total revenue hardly differ across the four scenarios. Only the composition of tax revenue changes.

First, it is clear that the wealth tax raises substantial revenue, of 2.3-3% of GDP. While this may appear small, it is more than the revenue from corporate income taxes in 2010,

[12] This requires a wealth tax rate of 0.735%.

[13] Piketty also proposes a tax of 5 or 10% on wealth above 1 billion Euros; this wealth level is not attained in the model.

Table 5: Aggregate outcomes: steady-state comparison

Scenario	K	N	Y	C	w	r (%)	ATY (%)	$w \times (1 - ATY)$
benchmark	100	100	100	100	100	2.8	24.2	100
wealth taxes:								
basic progressive	86.8	98.9	94.4	97.1	95.4	3.7	20.7	99.8
broad progressive	85.2	99.2	94.0	97.1	94.7	3.9	19.7	100.4
flat	89.9	100.0	96.2	98.6	96.2	3.5	20.3	101.1

Note: All values relative to the benchmark except for r and ATY.

Table 6: Composition of tax revenue (% of GDP): steady-state comparison

	Tax on					Total tax
Scenario	wealth	income	corporate income	estates	sales	revenue
benchmark	0	20.0	1.9	0.7	1.3	23.8
wealth taxes:						
basic progressive	2.4	17.7	2.3	0.4	1.3	24.1
broad progressive	3.0	17.0	2.4	0.4	1.3	24.1
flat	2.3	17.3	2.3	0.6	1.3	23.9

and about as much as the revenue from corporate income and estate taxes combined. This substantial new source of revenue allows reducing other taxes. Here, our assumption is that these are income taxes, via a reduction in λ. The decline in λ implies a reduction in income tax revenue from 20 to 17-18% of GDP, and a decline in the average income tax rate by about 4 percent points. This is a large decline relative to the level of this tax. In fact, it is so large that the after-tax wage at the average income tax rate is roughly constant across scenarios (see the last column of Table 5).

Hence, although the wealth tax crowds out investment and reduces the capital stock and wages, after-tax incomes of households relying mostly on labor income will not necessarily decline. For further detail, we next turn to the distributional implications of progressive wealth taxes.

5.2 Distributional implications of progressive wealth taxes

Table 7 shows the Gini coefficient and the distribution across wealth group of wealth, income, disposable income, earnings and consumption for the benchmark economy and the three wealth tax scenarios. The wealth tax scenarios feature roughly similar results except for the flat tax. We will mostly discuss results for the basic proposal.

Due to the high tax rate on large wealth holdings, the concentration of wealth declines significantly in this scenario, with a decline of the top 1% wealth share of around 10 percentage points. This is a large decline that almost entirely makes up for the increase in the top 1% wealth share between the 1960s and 2010. The top 5% and 10% wealth shares decline by similar amounts, driven uniquely by the decline in the top 1% share. The top 20% wealth share declines less, implying that the wealth share of the second decile increases.

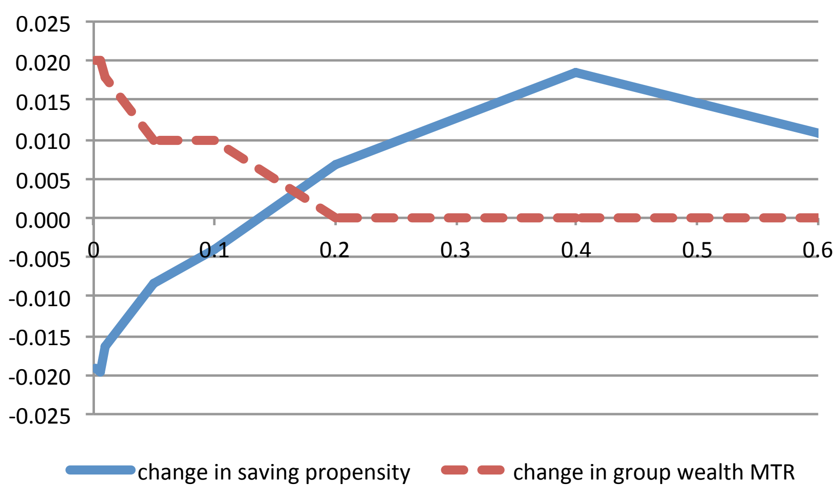

Figure 1: Change in the marginal tax rate on wealth and saving propensity by wealth group, comparison of basic wealth tax scenario and the benchmark economy

Note: The saving propensity is defined as $k' / (k + y^d)$.

Figure 1 shows the origin of these changes in the wealth distribution. Households in the top percentile of the wealth distribution significantly reduce their saving in response to higher wealth taxes. Households that face a wealth tax of around 1% reduce their saving very little since the increase r combined with lower income taxes roughly compensate them for higher wealth taxes. Thus, it is really households in the top percentile of the wealth who face lower returns to capital accumulation. Households below the top decile of the wealth distribution face no wealth tax but benefit from a higher return to saving and lower income taxes, so that they save more. This explains the increase in the wealth share of the second decile of the wealth distribution.

Results are very different for a flat wealth tax: here, all households face a tax rate of 0.735%, a return on capital that is about 0.7 percentage points larger, and lower income taxes. As a consequence, wealth concentration even increases slightly.

Although the basic wealth tax scenarios features much lower wealth concentration, the concentration of other variables does not change nearly as much. The top 1, 5 and 10% pre-tax income shares even increase. This is because changes in prices counteract the change in wealth concentration. For instance, the increase in r implies that even though the top 1% wealth share declines, the top 1% capital income share hardly changes.

The top 1 and 5% earnings shares actually increases, while the top 20% share declines. This is because the largest reduction in labor input occurs for groups just outside the top of the wealth distribution.

The concentration of disposable income hardly changes. This is both because of the direct effect of wealth taxes on income at the top, and because taxes decline more for households outside the top of the wealth distribution, making up for their lower income shares. Finally, the concentration of consumption diminishes noticeably, driven almost entirely by a decline in the share of consumption of the wealthiest 1% relative to the bottom 80% of the wealth distribution.

Table 8 shows average income tax burdens, computed as in Piketty and Saez (2007), by income group. This shows that although overall, higher wealth taxes lead to lower income taxes, this is less pronounced for top income groups. In absolute terms, of course, tax savings are largest at the top.

Tables 10 and 11 show further detail on changes in the distribution of the tax burden. First, note that in the basic scenarios, the top 1% of the wealth distribution pay 86% of the wealth tax, and the top 5% almost the entirety. These numbers are also large but slightly lower for the top of the income distribution. As a consequence, the tax system becomes significantly more progressive, in particular as a function of wealth: the share of total taxes paid by the wealthiest (highest-income) 1% rises from 18.6% (26%) to 27% (31.9%). This is because the share of income taxes paid by top income earners increases, even if income tax levels overall decline.

Table 7: Distribution of key variables: steady-state comparison

Scenario	Wealth group				Gini
	Top 1%	Top 5%	Top 10%	Top 20%	coefficient
Wealth:					
benchmark	52.0	73.2	85.5	98.1	0.922
basic wealth tax	40.7	62.7	75.4	93.2	0.875
broad wealth tax	42.9	64.7	78.2	94.1	0.885
flat wealth tax	52.9	74.1	86.2	98.4	0.925
Income:					
benchmark	14.0	28.3	39.7	54.9	0.534
basic wealth tax	14.3	29.9	39.5	54.5	0.531
broad wealth tax	14.6	29.4	40.1	55.1	0.534
flat wealth tax	15.1	29.7	41.1	55.8	0.539
Disposable income:					
benchmark	12.9	26.2	36.8	51.4	0.485
basic wealth tax	12.7	27.2	36.3	50.7	0.479
broad wealth tax	12.9	26.6	36.8	51.2	0.481
flat wealth tax	13.5	27.0	37.7	51.9	0.487
Earnings:					
benchmark	10.7	26.2	38.9	55.1	0.566
basic wealth tax	11.9	28.8	39.0	53.9	0.566
broad wealth tax	11.8	28.0	39.1	54.5	0.565
flat wealth tax	11.0	26.7	39.4	55.1	0.563
Consumption:					
benchmark	13.8	26.2	36.6	51.5	0.452
basic wealth tax	11.1	24.8	34.5	49.1	0.430
broad wealth tax	11.2	24.2	34.6	49.2	0.431
flat wealth tax	13.1	25.4	35.9	50.5	0.444

Table 8: Income tax burden for different income groups: steady-state comparison

	Income group				
Scenario	Top 1%	1-5%	5-10%	10-20%	Bottom 80%
benchmark	27.6	26.5	27.5	21.2	19.3
basic wealth tax	27.0	23.6	23.4	16.5	15.6
broad wealth tax	26.3	22.5	22.6	15.6	14.6
flat wealth tax	25.5	22.6	23.9	17.2	15.1

5.3 Welfare implications of progressive wealth taxes

We finally turn to a comparison of welfare for the different tax regimes. Table 9 shows differences in welfare relative to the benchmark economy for different wealth groups. *(Have to compute more meaningful welfare numbers in consumption units; in progress.)* These results line up closely with changes in the progressivity of the tax system: top wealth groups lose from the introduction of a progressive wealth tax, whereas groups outside the top 5% of the wealth distribution gain. In the aggregate, there is a slight gain from moving from the benchmark to a progressive wealth tax steady state. This is also true for the average worker or the average retiree (not shown in table).

Essentially these changes are aligned with changes in after-tax income for these groups. (Recall the result on after-tax earnings at the average tax rate above; since tax rates drop more at the bottom of the income or wealth distribution, the change in after-tax earnings is even more favorable for the poor.) This pattern is slightly mitigated by three factors: first, lower aggregate output implies lower transfers, which hurts the poor, for who transfers are most important. This is also the case for poor retirees. (Wealthy retirees benefit from higher r.) Second, households with a high temporary productivity state respond to the higher interest rate by working more to increase their precautionary saving. As a result of these two factors, there is some heterogeneity in terms of welfare changes among the bottom 80% of the wealth distribution. Low-wealth, low-productivity households lose, while households with moderate wealth and/or high productivity gain. Households with high wealth lose due to the direct effect of wealth taxes, no matter their productivity.

A third factor, however, is key for welfare gains among the bottom 80%: the higher interest rate encourages saving in this group. In particular, it reduces the fraction of households with zero wealth by a third. As a consequence, even if the value of certain

Table 9: Welfare for different wealth groups: steady-state comparison

Scenario	Wealth group				
	Top 1%	1-5%	5-10%	10-20%	Bottom 80%
Workers and retirees:					
basic wealth tax	-6.80	-0.19	0.35	0.62	0.22
broad wealth tax	-6.38	-0.36	0.12	0.02	0.25
flat wealth tax	-1.82	-0.73	-0.35	-0.76	0.16
Workers:					
basic wealth tax	-7.24	-0.21	0.39	0.22	0.22
broad wealth tax	-6.76	-0.34	0.16	-0.17	0.21
flat wealth tax	-2.02	-0.70	-0.30	-0.72	0.12
Retirees:					
basic wealth tax	-6.50	-0.97	0.64	1.63	0.25
broad wealth tax	-6.13	-1.04	0.20	0.72	0.33
flat wealth tax	-1.92	-1.21	-0.81	-0.70	0.17

productivity-(low-)wealth combinations declines with wealth taxes, the economy with progressive wealth taxes features fewer households at these states, and more households at better states with slightly more assets.

This is depicted in Figure 2, which shows value functions for productivity groups 1 and 3 for the benchmark economy and the basic progressive wealth tax scenario, and for retirees that retired from the lowest productivity group. The x-axis is truncated at ca. five times average wealth in the benchmark economy, implying that the figure omits the top 2% of the wealth distribution. It is clear from the figure that it is households above roughly the 80th percentile of the wealth distribution that directly benefit from the introduction of wealth taxes. Households with lower wealth levels lose – conditional on wealth.[14] However, the figure also shows how the 80th percentile of the wealth distribution increases with the introduction of wealth taxes, due to higher interest rates. Lower percentiles also increase. As a result, welfare for a household at the 80th percentile of the wealth distribution, or at any lower percentile where wealth holdings increase, actually increases because the positive effect of the shift in the wealth distribution dominates the negative direct effect of lower transfers.

Welfare and distributional effects of flat wealth taxes are completely different. First,

[14] Note that the top 1% of the wealth distribution, who are not visible in the figure, also lose.

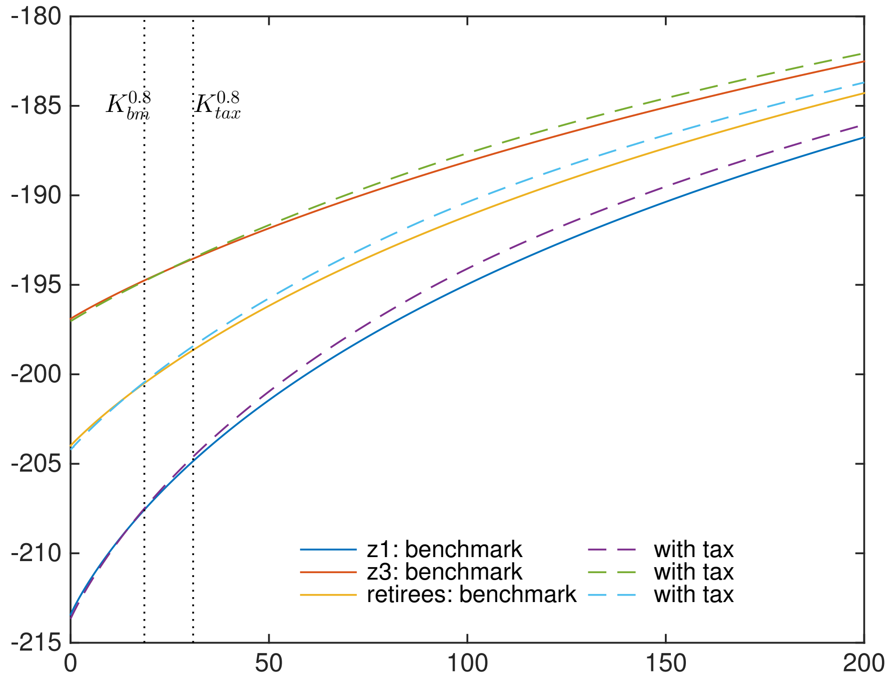

Figure 2: Value functions for selected productivity levels, benchmark and basic progressive wealth tax economies

flat wealth taxes do not reduce wealth inequality, as they affect saving incentives similarly for all wealth groups (Table 7). They do however reduce capital, output, consumption and pre-tax wages, albeit slightly less than progressive wealth taxes (Table 5). They also raise income inequality, as a consequences of the change in wealth inequality and equilibrium prices. As a result, aggregate welfare declines slightly compared to the benchmark (Table 9). This is driven by the opposite factors as with progressive wealth taxes: lower income taxes and a lower saving rate actually lead to larger welfare if the wealth distribution is fixed at its benchmark shape, but the long-run effect of lower saving (lower wealth) dominates, implying lower welfare.

6 The effect of progressive wealth taxes along the transition to the new stationary equilibrium

Since the steady states with wealth taxes feature a lower capital stock, the transition to the steady states under optimal saving behavior will take some time. Figure 3 shows the behavior of aggregate variables along this transition, for the case where the basic progressive wealth tax proposal is announced and implemented once and for all at $t = 0$. The parameter λ controlling that average income tax burden adjusts over time, clearing the government budget constraint every period. Prices adjust every period to clear factor markets.

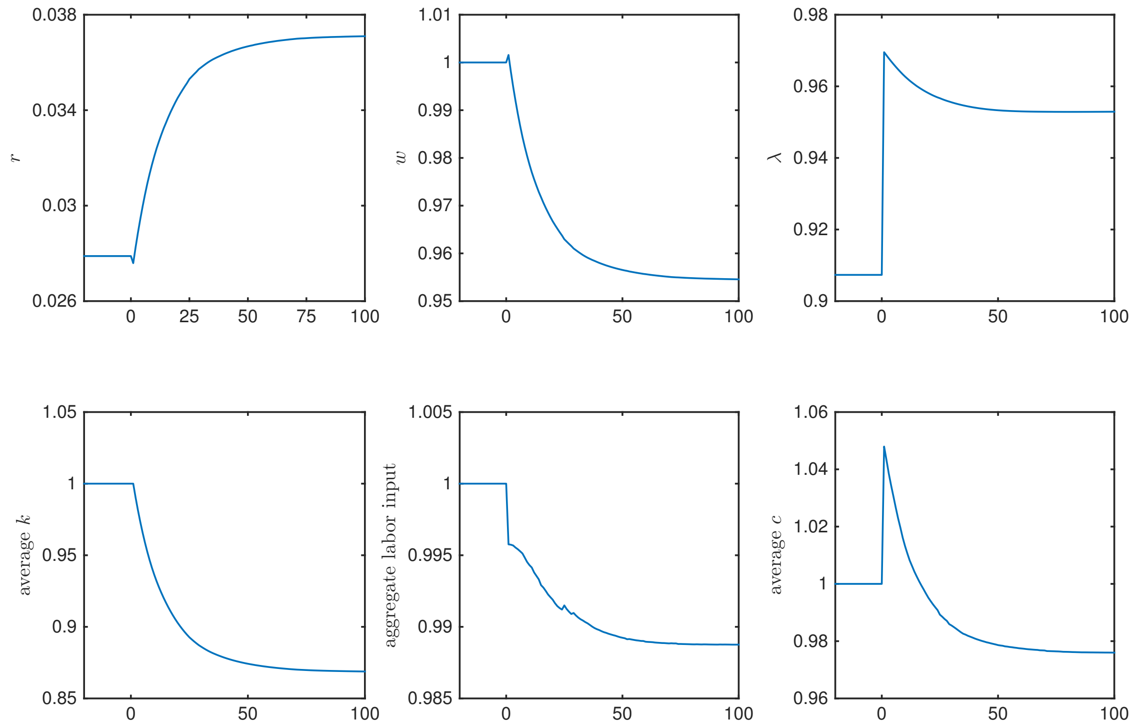

Figure 3: Aggregate outcomes along the transition

Values relative to the benchmark economy (= 1), except for r and λ. The new tax system with the basic progressive wealth tax scenario goes into effect at $t = 0$.

The transition, which involves a reduction in the capital stock of almost 15% as seen above, is almost entirely completed after 50 years. Over this period, the wage rate slowly declines and the interest rate slowly increases, mirroring the evolution of the aggregate capital-labor ratio. The parameter λ overshoots. The reason is that revenue from the wealth tax is larger upon implementation of the new tax system than later, when the capital stock is lower, implying that income taxes can be cut slightly more initially, but then later need to increase again to ensure budget balance. (See also Figure 4.)

The aggregate labor input declines by half a percent on the introduction of the new tax, and a bit more as the capital stock and wages decline. Average consumption jumps on impact and then gradually declines to its new, lower steady state value. It exceeds

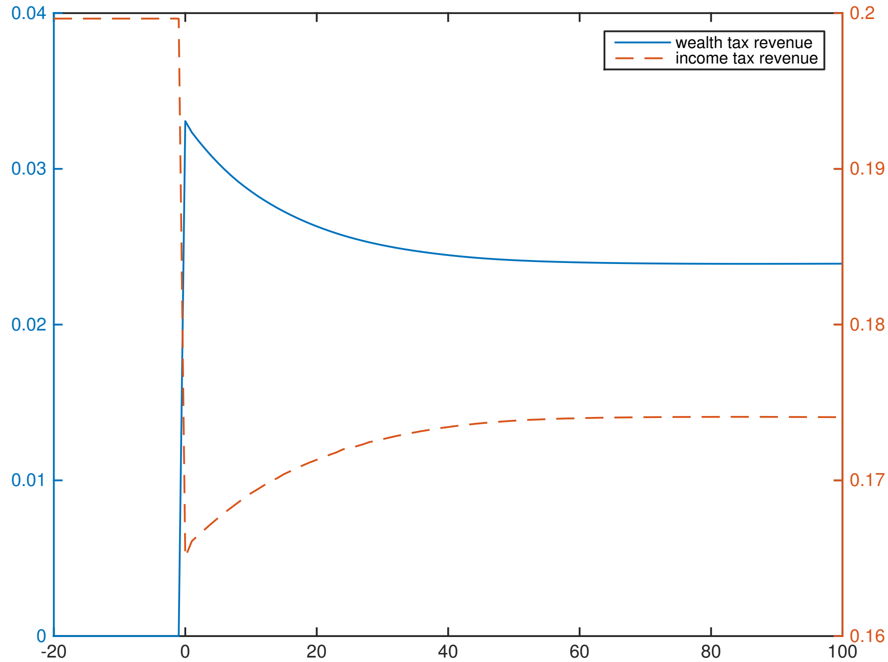

Figure 4: Revenue from wealth and income taxes (% of GDP) over the transition

Note: Income tax revenue on the right axis.

its value in the initial steady state for sixteen years and only drops below it once already almost 10% of the initial capital stock have been consumed.

Given that average household value in the basic wealth tax steady state exceeds that in the benchmark *and* that steady state features a lower capital stock, one would think that the transition to the new steady state should be even more favorable than the steady state, since capital can be consumed along the way. Figure 5 shows that this is not the case. Instead, $V(k,z)$ drops for all (k,z). The figure shows, for selected values of z, that it takes a very long time for the average value per z to recover, and even more before it eventually exceeds the benchmark value.

The reason for this is the change in the wealth distribution described in Table 7: with wealth taxes, wealth concentration declines not only because of reduced wealth accumulation at the top, but also because low-wealth households hold slightly more wealth. In fact, 83 to 99% of all households at "regular" states optimally save more in the basic wealth tax steady state. This is very similar already in the first year of the transition. This implies that most households, and in particular those with large welfare weights,

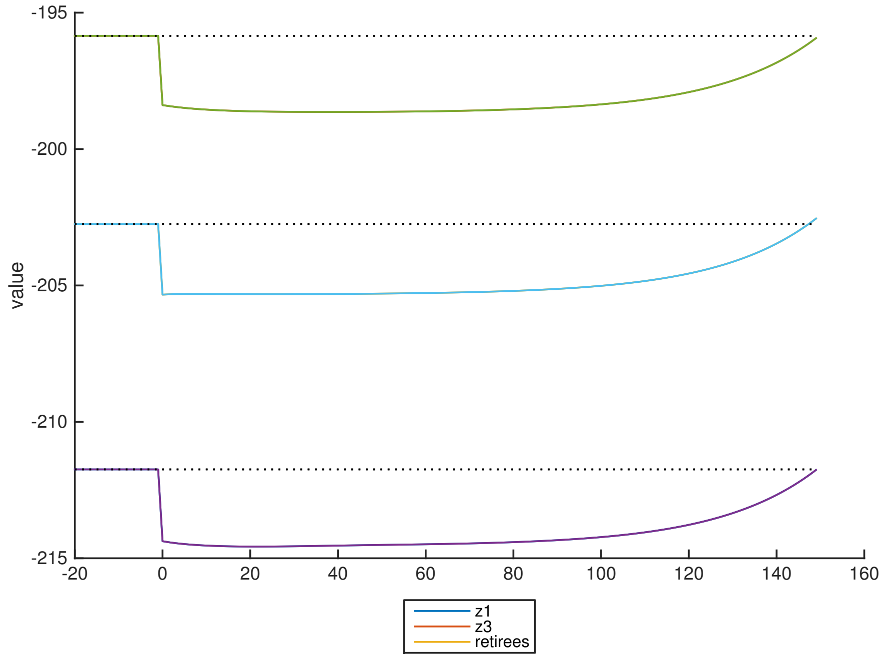

Figure 5: Average value of value functions for selected productivity levels, transition from benchmark to steady state with basic progressive wealth tax

spend the transition accumulating assets. Only households that are very wealthy in the benchmark steady state decumulate assets over the transition. As a result, the transition is costly for most households. This implies that even if average welfare is higher in the basic wealth tax steady state, undertaking the transition to it is not desirable because of the additional saving effort required from most households.

7 Discussion

Our results suggest that a progressive wealth tax could raise substantial revenue, even in the fact of saving and labor supply reactions. (Recall that we ignore tax avoidance.) While it has large negative effects on aggregate capital formation and wages, it would not reduce welfare when comparing steady states. This is because the wealth tax revenue allows reductions in other taxes (here, income taxes), and because the higher interest rate it brings about encourages saving by the bottom 80% of the wealth distribution. Once this group has accumulated additional wealth, it is better off than in the benchmark. Since accumulating wealth is costly, welfare does decline from an ex ante perspective.

How do these results compare to those of other studies? Piketty (2014, Chapter 15 and online appendix) discusses the effect of introducing wealth taxes as in the basic and the broad scenarios. He finds very similar potential for the wealth tax in terms of potential to raise revenue for the basic scenario, at 1.8% of GDP compared to 2.4% of GDP in our results. Among other things, the difference here stems from the fact that his analysis is for the European Union, where wealth is less concentrated than in the US. For the broad setting, with a 10% top rate, his simulations yield revenue of 3.9% of GDP, compared to 3% in our analysis. Here, the difference arises because he does not face the difficulty of generating household wealth above 100 million euros endogenously, since the wealth distribution is exogenous in his analysis.

Piketty does not evaluate quantitatively how the tax would affect aggregates, or even the distribution of wealth. First, the reduction in aggregate output and wealth predicted in our analysis implies that the level of wealth tax revenues would be lower than that predicted by Piketty, even if revenue as a fraction of GDP is similar. Secondly, even with a zero welfare weight on high wealth groups, it is not obvious that taxing the wealthy is welfare improving because of general equilibrium effects. Piketty completely abstracts from these effects.

Schuyler (2014) attempts to capture some of these effects, and predicts effects of potential top wealth taxes in the United States on capital, wages and output that are very close to the effects shown in Table 5. This is surprising, given that Schuyler (2014) also predicts only very low revenue from the wealth tax, of just a bit more than 0.1% of GDP. It is also unclear what Schuyler (2014) assumes on the use of this revenue. As a consequence, no further distributional or welfare statements can be made.

Our analysis in contrast not only endogenizes the response of aggregate variables, but also allows for a full distributional and welfare analysis of the effects of progressive wealth taxes. Only in this way can subtle results like the tension between the short-run and long-run effects of these taxes be obtained. Currently, we are in the process of refining the calibration to provide a better fit to the US economy. An important next step is to compare th effect of progressive wealth taxes to other, closely related progressive taxes, e.g. on consumption.

A Additional Tables and Figures

Table 10: Distribution of the tax burden across income groups: steady-state comparison

	Income group				Gini
Scenario	Top 1%	Top 5%	Top 10%	Top 20%	coefficient
Total taxes:					
benchmark	26.0	42.4	59.9	78.3	0.640
basic wealth tax	31.9	48.4	65.2	81.8	0.693
broad wealth tax	32.5	49.1	66.3	82.5	0.707
flat wealth tax	30.3	47.1	64.2	82.4	0.695
Wealth tax:					
benchmark	—	—	—	—	—
basic wealth tax	66.2	84.1	89.0	99.3	0.987
broad wealth tax	56.0	73.6	82.9	96.4	0.958
flat wealth tax	38.8	58.6	72.8	90.0	0.925
Income tax:					
benchmark	23.4	39.1	57.4	76.2	0.622
basic wealth tax	26.1	42.0	60.7	77.7	0.649
broad wealth tax	26.8	42.7	61.9	78.0	0.659
flat wealth tax	26.0	41.6	60.2	79.1	0.655
Income tax, workers only:					
benchmark	26.4	44.1	64.8	85.5	0.661
basic wealth tax	29.2	47.1	68.0	85.8	0.685
broad wealth tax	29.9	47.7	69.0	86.0	0.694
flat wealth tax	29.0	46.4	67.2	87.6	0.690
Corporate income tax:					
benchmark	40.4	60.0	74.6	91.8	0.946
basic wealth tax	34.8	52.0	70.0	92.5	0.916
broad wealth tax	36.8	54.9	72.3	93.4	0.925
flat wealth tax	43.3	63.6	76.8	94.2	0.946

Table 11: Distribution of the tax burden across wealth groups: steady-state comparison

Scenario	Wealth group				Gini
	Top 1%	Top 5%	Top 10%	Top 20%	coefficient
Total taxes:					
benchmark	18.6	34.7	47.2	63.2	0.640
basic wealth tax	27.0	44.5	54.1	68.3	0.693
broad wealth tax	27.9	44.9	56.1	70.7	0.707
flat wealth tax	25.0	42.5	55.1	70.2	0.695
Wealth tax:					
benchmark	—	—	—	—	—
basic wealth tax	86.0	97.5	100.0	100.0	0.987
broad wealth tax	72.0	86.6	93.5	99.3	0.958
flat wealth tax	52.9	74.1	86.2	98.4	0.925
Estate tax:					
benchmark	99.7	100	100	100	0.996
basic wealth tax	100	100	100	100	0.997
broad wealth tax	100.0	100	100	100	0.997
flat wealth tax	99.8	100	100	100	0.996

References

Aiyagari, Rao. 1994. "Uninsured Idiosyncratic Risk and Aggregate Saving." *Quarterly Journal of Economics* 109 (3):659–684.

Aiyagari, S. R. 1995. "Optimal Capital Income Taxation with Incomplete Markets, Borrowing Constraints, and Constant Discounting." *Journal of Political Economy* 103 (6):1158–1175.

Bach, S. and A. Thiemann. 2016. "Reviving Germany's Wealth Tax Creates High Revenue Potential." *DIW Economic Bulletin* 4+5.

Badel, A. and M. Huggett. 2014. "Taxing Top Earners: A Human Capital Perspective." Federal Reserve Bank of St. Louis Working Paper: 2014-17.

Bakış, Ozan, Barış Kaymak, and Markus Poschke. 2015. "Transitional dynamics and the optimal progressivity of income redistribution." *Review of Economic Dynamics* 18 (3):679–693.

Bewley, T. 1986. *Contributions to Mathematical Economics: In honor of Gerard Debreu*, chap. Stationary Monetary Equilibrium with a Continuum of Independently Fluctuating Consumers. New York: North Holland, 79 – 102.

Blundell, R., L. Pistaferri, and I. Saporta-Eksten. 2012. "Consumption Inequality and Family Labor Supply." *NBER Working Paper* 18445.

Castaneda, A., J. Diaz-Gimenez, and J. V. Rios-Rull. 2003. "Accounting for the U.S. Earnings and Wealth Inequality,"." *Journal of Political Economy* 111 (4):818–857.

Chamley, C. 1986. "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives." *Econometrica* 54 (May):607–22.

Chamley, Christophe. 2001. "Capital income taxation, wealth distribution and borrowing constraints." *Journal of Public Economics* 79 (1):55–69.

Conesa, Juan Carlos, Sagiri Kitao, and Dirk Krueger. 2009. "Taxing Capital? Not a Bad Idea After All!" *The American Economic Review* 99 (1):25–48.

Diaz-Gimenez, J. A., A. Glover, and V. Ríos-Rull. 2011. "Facts on the Distributions of Earnings, Income, and Wealth in the United States: 2007 Update." *Federal Reserve Bank of Minneapolis Quarterly Review* 34:2–31.

Gravelle, Jane. 2014. *International Corporate Tax Rate Comparisons and Policy Implications*. Washington, DC: Congressional Research Service.

Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura. 2014. "Income taxation of US households: Facts and parametric estimates." *Review of Economic Dynamics* 17 (4):559–581.

Guner, Nezih, Martin Lopez Daneri, and Gustavo Ventura. 2014. "Heterogeneity and Government Revenues: Higher Taxes at the Top?" *mimeo* .

Guvenen, Fatih, Gueorgui Kambourov, Burhan Kuruscu, Sergio Ocampo, and Daphne Chen. 2016. "Use it or Lose It: Efficiency Gains from Wealth Taxation." *mimeo, U of Minnesota* .

Heathcote, J., F. Perri, and G. Violante. 2010. "Unequal we stand: An empirical analysis of economic inequality in the United States, 1967 - 2006." *Review of Economic Dynamics* 13 (1):15 – 51.

Heathcote, Jonathan, Kjetil Storesletten, and Gianluca Violante. 2014. "Optimal Tax Progressivity: An Analytical Framework." *Federal Reserve Bank of Minneapolis Research Department Staff Report* 496.

Huggett, M. 1993. "The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies." *Journal of Economic Dynamics and Control* 17 (5-6):953–69.

Jokisch, Sabine and Laurence J Kotlikoff. 2007. "Simulating the Dynamic Macroeconomic and Microeconomic Effects of the FairTax." *National Tax Journal* :225–252.

Joulfaian, David. 2013. "The Federal Estate Tax: History, Law and Economics." US Department of Treasury - Office of Tax Analysis.

Judd, Kenneth L. 1985. "Redistributive taxation in a simple perfect foresight model." *Journal of Public Economics* 28 (1):59–83.

Kaymak, Barış and Markus Poschke. 2016. "The evolution of wealth inequality over half a century: The role of taxes, transfers and technology." *Journal of Monetary Economics* 78.

Keister, L. A. and S. Moller. 2000. "Wealth Inequality in the United States." *Annual Review of Sociology* 26:63–81.

Kindermann, Fabian and Dirk Krueger. 2014. "High Marginal Tax Rates on the Top 1%? Lessons from a Life Cycle Model with Idiosyncratic Income Risk." NBER Working Paper No: 20601.

Kocherlakota, Narayana R. 2005. "Zero expected wealth taxes: A Mirrlees approach to dynamic optimal taxation." *Econometrica* 73 (5):1587–1621.

Kopczuk, W., E. Saez, and J. Song. 2010. "Earnings Inequality and Mobility in the United States: Evidence from Social Security Data since 1937." *Quarterly Journal of Economics* 125 (1):91 – 128.

Kopczuk, Wojciech. 2015. "What do we Know About Evolution of Top Wealth Shares in the United States?" *Journal of Economic Perspectives* 29 (1):47–66.

Krueger, Dirk and Alexander Ludwig. 2013. "Optimal Progressive Taxation and Education Subsidies in a Model of Endogenous Human Capital Formation." Penn Institute for Economic Research Working Paper.

Panousi, Vasia and Catarina Reis. 2015. "Optimal capital taxation with idiosyncratic investment risk." *manuscript* .

Piketty, Thomas. 2014. *Capital in the Twenty-First Century*. Cambridge, MA: Congressional Research Service.

Piketty, Thomas and Emmanuel Saez. 2003. "Income Inequality in the United States." *Quarterly Journal of Economics* 118 (1):1–39.

———. 2007. "How Progressive is the U.S. Federal Tax System? A Historical and International Perspective." *Journal of Economic Perspectives* 21 (1):3–24.

Saez, Emmanuel. 2013. "Optimal progressive capital income taxes in the infinite horizon model." *Journal of Public Economics* 97:61–74.

Saez, Emmanuel and Gabriel Zucman. 2014. "Wealth Inequality in the United States since 1913: Evidence from Capitalized Income Tax Data." NBER Working Paper 20625.

Schuyler, Michael. 2014. "The Impact of Piketty's Wealth Tax on the Poor, the Rich, and the Middle Class." *Tax Foundation Special Report* 225.

Shourideh, Ali. 2012. "Optimal taxation of wealthy individuals." *mimeo, University of Pennsylvania* .

Solon, G. 1999. *Handbook of Labor Economics*, vol. 3, chap. 29. Amsterdam, NY: Elsevier Science B. V.

Straub, Ludwig and Iván Werning. 2014. "Positive Long Run Capital Taxation: Chamley-Judd Revisited." *National Bureau of Economic Research Working Paper* 20441.