

The evolution of wealth inequality over half a century: the role of skills, taxes and institutions

Barış Kaymak*

Université de Montréal and CIREQ

Markus Poschke[†]

McGill University and CIREQ

First Draft for SED 2015, Warsaw. Do NOT distribute.

Abstract

Over the last 50 years, the US economy saw significant changes in its fiscal structure. Notable among these are the introduction and expansion of social security programs and Medicare, and the transformation of the tax system. These institutional changes took place against a backdrop of developments in the technology of production that increasingly favored skilled workers. In this paper, we analyze how the interplay between these institutional and technological factors might have shaped the distributions of income, wealth, consumption and welfare. We find that while changes in income inequality are mostly attributable to technological factors, the increase in wealth inequality has further been compounded by the expansion of social security and Medicare, which have reduced saving incentives for retirement, in particular for low and middle income groups. As a result, they have substantially increased wealth concentration in US. Results suggest that approximately 25% of the rise in the share of wealth held by the wealthiest 1% is explained by larger transfers to senior population.

J.E.L. Codes: E32, J31, J41

Keywords: Tax Progressivity, Social Security, Medicare, Skill-biased Technical Change, Income Inequality, Wealth Inequality, Top 1%, Saving

*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

1 Introduction

Over the last 50 years, the US economy saw significant changes in its fiscal structure. Notable among these are the introduction and expansion of social security programs and Medicare, and the transformation of the tax system. These institutional changes took place against a backdrop of developments in the technology of production that increasingly favored skilled workers. Over the same period income and wealth inequality increased dramatically (Piketty and Saez, 2003; Heathcote, Storesletten, and Violante, 2010; Wolff, 1998; Saez and Zucman, 2014). In this paper, we link these developments, and analyze quantitatively how technological and institutional factors have affected the evolution of inequality since 1960.

In terms of outcomes, we focus particularly on wealth inequality. This is not simply a mirror of the distribution of wages, but results from its interaction with institutions, which shape labor supply and savings behavior. In terms of determinants, we take into account changes in all three drivers of inequality named above, but focus particularly on the effect of changes in government transfers to retirees on inequality. Transfers exert an important influence on the wealth distribution, as they affect the incentive to save of different income and wealth groups differentially.

Between 1960 and 2010, federal transfers to seniors as a fraction of GDP more than tripled. Expenditures on social security and Medicare benefits increased from about 2.5% of GDP to 8.5%. Medicare, which did not exist in 1960, now accounts for almost half of this. Social security coverage was already broad in 1960, covering around 75% of the senior population and 85% of employment, but the following 50 years saw significant increases in benefits per retiree at all income levels. Replacement rates, defined as the ratio of retirement benefits to past earnings, increased most at the bottom of the income distribution.

These changes in transfers occurred alongside a tax system that became less progressive. First, revenue from corporate income taxes as a fraction of GDP declined by about half, driven both by lower rates and larger exemptions. This affected the return to financial assets, which are mostly owned by relatively wealthy households. Secondly, estate tax rates declined, in particular for large estates, and the estate tax exemption level increased dramatically. Again, revenue halved. Thirdly, marginal tax rates applied to very high incomes declined significantly.

It is clear that all of these channels have the potential to affect inequality, not just of

wages, but also of earnings, income, consumption, and wealth. All of these have increased substantially over the period under consideration (Piketty and Saez, 2003; Heathcote, Storesletten, and Violante, 2010; Wolff, 1998; Saez and Zucman, 2014; Aguiar and Bils, 2011). For instance, while the wealthiest 1% of tax units held 28% of all wealth in the US 1960, they owned 40% in 2010. Similarly, the share of income accruing to the top 1% of the income distribution doubled from 10% in 1960 to 20% in 2010.

In general, it is plausible that increased wage inequality, which has been well documented, could lead to increased inequality in earnings, income, and wealth. This is immediately obvious when households do not adjust their labor supply or savings in response to changes in prices or institutions. But of course, such adjustments do occur. When saving rates adjust in response to such changes, institutional changes may gain importance as drivers of wealth inequality.

A key such change is the expansion of social security. By weakening the motive to save for retirement, it may lead to reduced savings for all households, but with effects that differ by income and wealth. As we show in detail in Section 2, the system of government transfers to the elderly in place in the United States became significantly more progressive between 1960 and 2010. This is due to both a larger increase in social security replacement rates for low- relative to high-earning households, and to an expansion in programs with income-independent benefits, like Medicare. These policy changes may not affect saving of the wealthy much – income from social security is small relative to other sources of income for wealthy retirees, even after the increase in benefits – but may significantly reduce that of the poor. As a consequence, the expansion of social security may reduce saving rates below the top of the wealth distribution and, as a consequence, raise the share of private wealth held by the wealthiest households.

The same is true for changes in the tax system. Changes in the progressivity of the income tax system change after-tax incomes of different income groups, and thus their relative saving capacity. Changes in capital income taxes change the return to saving. Several such changes have occurred, and may have played a role in the evolution of wealth inequality.¹

¹Along these lines, Piketty and Saez (2003) suggest that the highly progressive tax system in place after World War II may have led to low wealth shares of top income groups in that period, due to both the direct effect of taxes and incentive effects on saving. They also suggest that subsequent tax cuts raised returns to saving and thereby contributed to increased wealth inequality. For a more detailed analysis of the effect of taxes on top incomes on wealth inequality, see Kaymak and Poschke (2014). For analyses of optimal taxation of the top 1% income earners, see Badel and Huggett (2014), Kindermann and Krueger (2014) and Lopez Danieri, Guner, and Ventura (2014). For a recent empirical analysis of changes in income taxes on

We conduct our analysis using a dynamic macroeconomic model of consumption and savings with uninsurable idiosyncratic income risk and endogenous labor supply building on Aiyagari (1994); Bewley (1986); Huggett (1993). This general equilibrium heterogeneous agent model is capable of generating realistic patterns of income and wealth inequality. Households in the model have three motives for saving: a precautionary savings motive to insure against income risk during their lifetime, a consumption smoothing motive to save for retirement, and a bequest motive to endow estates. The first motive arises because a household's labor productivity is subject to shocks. The second motive arises due to the demographic structure in the model, which closely follows the *neda*, Díaz-Giménez, and Ríos-Rull (2003) implementation of these models. Households in the model go through the life-cycle stages of work, where they face idiosyncratic income risk, and retirement, where they live off their pension income and private wealth. The third motive arises because upon death, households are replaced by their offspring, to whom they are fully altruistic. While all households experience all three saving motives, their strength will depend on a household's productivity and wealth.

We augment this setting by a detailed modeling of transfers and taxes. While working, households pay income taxes (including payroll taxes) and consumption taxes. The government also levies corporate income taxes. Transfers of estates are subject to estate taxes. We model all of these taxes in a way that closely resembles taxes in place in the United States. Retired households receive a transfer that is linked to past earnings and is modelled using social security benefit formulas, and a fixed transfer representing benefits that are common across retirees, like Medicare. This transfer system is financed by taxes in a pay-as-you-go way. In their labor supply and saving choices, households react to taxes they face, and take into account future benefits they will receive.

We calibrate the model to match the life-cycle and intergenerational transitions in earnings as well as the overall income and wealth distributions in the 1960s. We then change parameters of technology and institutions in line with observed changes in the US economy since then. In particular, we introduce a rising cross-sectional dispersion of labor efficiency, expand social security, introduce a fixed transfer to the elderly representing Medicare, and reduce corporate income taxes, estate taxes, and the top marginal income tax rate. After introducing these changes, the model closely matches the distributions of income and wealth in the US economy in 2010. To gauge the contribution of each change separately, we return to the 1960 economy and introduce each change individually, sim-

incomes, see Mertens (2013).

ulating counterfactual economies where only a single change occurred. This allows us to determine for which fraction of the overall change each element accounts, and allows us to discern potential interactions between changes in institutions and technology.

We find that while changes in inequality are mostly attributable to changes in the return to skill, the increase in wealth inequality has further been compounded by the expansion of social security and Medicare. As conjectured above, expanding social security and introducing Medicare in the model reduces saving incentives of the bottom 90% of the wealth distribution strongly, while the effect on saving rates at the top of the wealth distribution is barely discernible. The reason is that transfers have increased by a large amount relative to incomes of the bottom 90%, with a replacement rate that increased from around 30% to three quarters, while they have remained very small compared to incomes of the wealthy. Reduced saving by the wealth-poor implies that their share of the distribution of private wealth shrinks, and the share of the wealthiest groups grows. As a result, the expansion of transfers can account for a quarter of the increase in the top 1% private wealth share between 1960 and 2010. Since saving reactions within the bottom 90% are much less heterogeneous, other measures of wealth inequality that focus on inequality throughout the distribution, like the Gini coefficient of the wealth distribution, increase much less.

Although increased transfers lead to reduced saving, they nonetheless lead to reduced inequality of income between workers and retirees. The reason for this is that for retirees, transfer receipts more than make up for reduced capital income. As a consequence, the expansion of transfers is linked to a substantial decline in the Gini coefficient of the distribution of income in the entire population, while it hardly affects the Gini coefficient of the income distribution among workers.

Compared to transfers, changes in taxes have a very minor effect on top wealth shares. They even reduce the top 1% share. This occurs because observed tax changes stimulate saving by the top 1-10% much more than saving by the top 1%. This result is in line with our earlier findings (Kaymak and Poschke, 2014). Increasing wage inequality, in contrast, accounts for a large portion of the change in wealth concentration, and also for the entirety of changes in income inequality. When considering the entire population, this last change is almost fully compensated by larger benefits.

In ongoing work, we also analyze the timing of changes in wage inequality and institutions. The empirical literature cited above reports that wealth inequality increased with a substantial lag compared to the increase in wage inequality. This could have several rea-

sons. First of all, since wealth is a stock that needs to be accumulated, it could simply be that an increase in wage inequality takes time to translate into larger wealth inequality. However, it is also possible that existing institutions counteracted higher wealth inequality in a period of already increasing wage inequality, and that this effect changed once institutions changed. Finally, it could be that the change in institutions itself – which occurred mostly in the 1970s and 1980s – led to increased wealth inequality. Simulating the transition from 1960 to 2010 in the model, with technology and institutions that change along the transitions, will lead to additional insights.

There is a substantial literature on the effect of tax reforms. We highlight a few closely related studies using quantitative macro models. Using a similar setup, *neda*, Díaz-Giménez, and Ríos-Rull (2003) find that reducing a flat estate tax from 17% to zero results in slight increases of top wealth shares (including the top 1%) and in the capital stock. Their analysis of a hypothetical tax cut does not address the non-linearity of the cut that actually occurred, and does not consider its interaction with the contemporaneous increase in wage inequality. Cagetti and de Nardi (2009) also analyze abolition of the estate tax, and focus on its differential effect on the investment decisions of large and small firms. Domeij and Heathcote (2004) study the welfare implications of reducing the capital income tax from 40% to zero. They do not focus on matching the top of the wealth distribution, nor do they report how it changes with the tax experiment. Two recent papers focus on the taxation of top income earners more specifically: Badel and Huggett (2014) and Kindermann and Krueger (2014) both explore what the optimal marginal tax rate on income of the top 1% income earners should be. Given their focus on income taxes, they consider neither changes in estate or corporate income taxes, nor the role of changing wage inequality. Finally, on the empirical side, Mertens (2013) finds using U.S. time series data that changes in top marginal income tax rates have substantial effects on top income shares. His analysis does not consider corporate income or estate taxes nor wealth inequality, and is therefore complementary to ours.

The literature on increasing wage inequality is similarly large. Here, we only highlight a small number of papers analyzing the effect of increasing wage inequality on other economic outcomes. Notably, Heathcote, Storesletten, and Violante (2010) analyze the effect of increasing wage inequality on trends in the inequality of hours worked, earnings, consumption, and welfare, but not on wealth inequality. Heathcote, Storesletten, and Violante (2014) provide results on how optimal progressivity of income taxes responds to changes in the size of uninsurable idiosyncratic productivity shocks, but analyze neither

estate and corporate income taxes nor the effect on wealth inequality.

In what follows, we first provide a brief discussion of the major changes in transfers to the elderly and in the US tax code in the post-WWI period. Section 3 presents the model and Section 4 explains the calibration of the model parameters. Section 5 explores how well the model fits the US economy in 1960. The main findings are reported in Section 6, where we use counterfactual simulations to evaluate the impact of social security, rising wage inequality and tax changes on the economy. Section 7 [in progress] reports results on the simulated transition from 1960 to 2010. Section 8 concludes.

2 Changes in transfers to the elderly and in the US tax system

This section gives a brief overview over changes in transfers to the elderly (social security and Medicare) and in the tax system in the United States. We pay particular attention to how these changes affected different income and wealth groups differently.

2.1 Transfers to the elderly: Social Security and Medicare

Over the period 1960 to 2010, there have been two major developments in policies that are targeted at senior citizens: the expansion of the social security system, and the introduction and expansion of Medicare. We argue that these programs have discouraged wealth accumulation by low and middle income groups. Figure 1 shows the share of each component relative to GDP since 1940. The foundations of the current social security system were legislated by the Congress in 1935. The Social Security Administration started collecting payroll taxes to establish its funds in 1937, and first regular benefit payments began in 1940. The following couple of decades saw several amendments to the law that expanded the coverage of workers under the social security program. By 1960, close to 90% of the civilian workforce was covered under the social security program, and about 75% of seniors collected benefits in some form. Therefore, the rise in benefits payments relative to GDP between 1940 and 1960 is largely attributable to the expansion of coverage.

During the 1970s, the program went through a second phase of expansion not in coverage of persons but in terms of generosity of benefits. The 1972 legislation introduced automatic adjustments based on wage and price inflation and introduced the supplemental security plan for seniors who had little or no source of income (largely because

they worked outside the social security system). These changes led to a sharp increase in transfer payments relative to the GDP until the 1980s, when amendments to automatic adjustment policies stabilized the benefit payments relative to output.

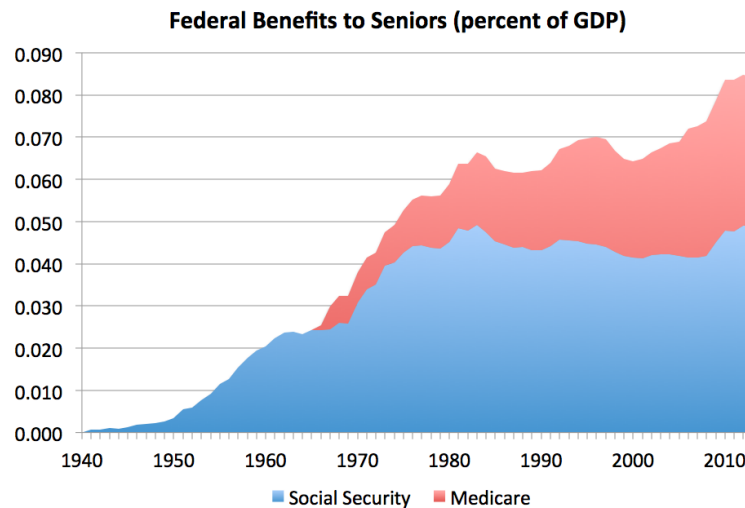


Figure 1: Federal benefits to seniors (percent of GDP)
Source: NIPA.

While the share of seniors in the total population has been steadily rising in the US, the rise in social payouts is not explained by demographic changes. Figure 2 shows the real average payout per beneficiary since 1950 under the two major programs. So-called insurance payments, which constitute the bulk of total payouts, have increased three-fold over the course of 60 years. The increases early on after the inception of the program are driven partly by larger entitlements as workers retired having contributed into the system for a longer period and partly due to sporadic raises in benefit amounts legislated by Congress. A third factor that contributed to the rise in real benefits was real average growth after the Second World War that lasted until the early 1970s. Even though real wages were stable during the following years, the impact on real benefits lingered for several decades since benefit amounts are calculated based on a worker's entire earnings history and, therefore, workers who contributed to the social security fund during the 1950s and 1960s retired with increasingly higher benefits.

In addition to the growth in the size of the social security program, the formulas that link social insurance benefits to one's earnings history have traditionally been redistributive, and have evolved to be more progressive over the years. Figure 3a compares the initial Simplified Old Start Formula that was used until 1958 with the current formula

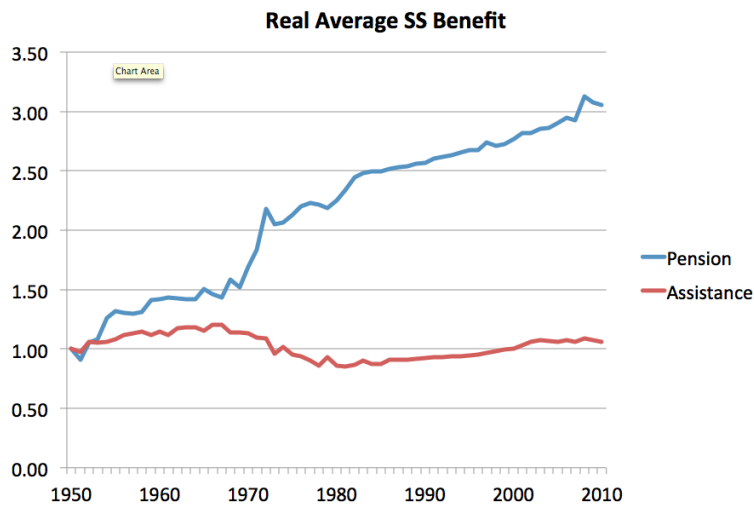


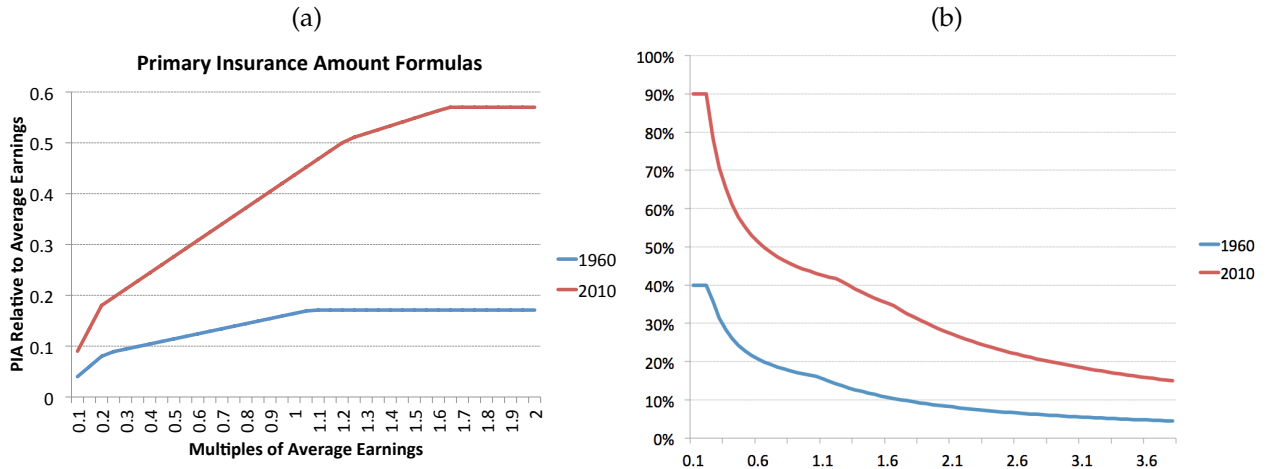
Figure 2: Real average social security benefit (1950=1)
Source: SSA.

adopted by the SSA. Each formula determines the monthly benefit amount as a function of average (allowable) earnings during a worker's career. Both variables are expressed relative to average earnings to maintain comparability. Both formulas yield piecewise linear functions with a cap on benefits for those with higher earnings. Figure 3b shows the implied replacement rates (obtained by dividing the value on the vertical axis by the value on the horizontal axis). The fact that the replacement rate is a decreasing function of income shows the redistributive nature of the formulas. From 1960 to 2010, the replacement rate for a worker with average earnings has increased from 16% to 44%. However, the increase in the replacement rate has been asymmetric across the earnings distribution. While the replacement rate for the lowest earnings groups increased from 40% to 90%, that for a worker with three times average earnings only increased from 6% to 19%. In 1960, such a worker would have been at the 90th percentile of the earnings distribution. For comparison, in 2010, a worker at the 90th percentile of the earnings distribution has four times average earnings.

The second largest program that primarily targets senior citizens is Medicare, which is a national healthcare insurance program.² It was started in 1966, and expanded greatly both in coverage and benefits since then. Currently, federal expenditures on Medicare stand around 4.3% of the US GDP.

²Medicare also contains a disability insurance component starting in 1973, which currently constitutes 19% of all beneficiaries.

Figure 3: Benefit Calculation Formulas



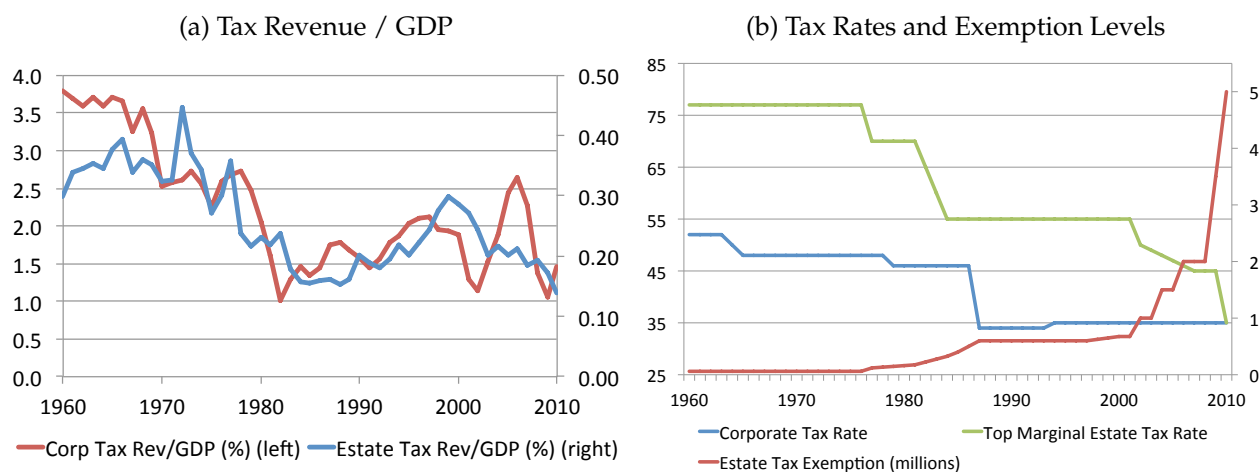
Source: Authors' calculations based on the Social Security Handbook and the 2013 Bulletin of the SSA.

Both the heterogeneous changes in replacement rates and the fixed nature of benefits from other expanding programs such as Medicare imply that changes in transfers affect the savings incentives of workers with different levels of income and wealth differentially. Clearly, the expansion of the social security replacement rate to 90% for a very low-income worker will strongly affect that worker's saving incentive; much more so than the moderate expansion seen for high-income workers. As a consequence, the expansion of transfers can lead to shifts in the wealth distribution. Before turning to the model we use for our quantitative evaluation, we next briefly describe changes in the tax system over the last 50 years.

2.2 The US Tax System

The US tax system went through several changes in the last 50 years that particularly benefited the top income groups. The two major components of this transformation are reductions in taxes imposed on corporations and on the transfer of large estates. Figure 4 shows that from 1960 to 2010, total revenue from each of these taxes expressed as a share of GDP declined by about half. In the case of corporate taxes, the decline resulted both from more generous allowances for depreciation expenses and from lower marginal tax rates. The statutory tax rate on corporate income declined from 52% in 1960 to 35% in 2010. A similar pattern is seen in the effective marginal taxes on corporate income, which take into account tax exemptions and allowances and therefore are usually lower than

Figure 4: Corporate and Estate Taxes: 1960 - 2010



the statutory rate. Gravelle (2004) and Gravelle (2014) report that the average effective marginal tax rate on corporate profits declined from 42.0% in 1960 to 23.6% in 2010.

For estate taxes, the decline in revenues stems from a combination of an increase in the exemption level and lower top marginal tax rates. The exemption level in 1960 was 60 thousand dollars, or approximately 1.7 times average wealth then, whereas in 2010, the exemption level was as high as 5 million dollars, or approximately 10 times average wealth. As shown in Figure 5, marginal rates also declined, with the top marginal rate declining from 77% in 1960 to 35% in 2010. As a consequence, marginal estate tax rates dropped by about 30 percentage points for estates corresponding to percentiles 10 to 0.6 of the wealth distribution, and by a variable but large amount at the very top of the distribution. In the analysis below, we will use the estate tax schedules exactly as depicted in Figure 5.

Since ownership of corporate assets and wealth is highly concentrated in the hands of the top income groups, this change benefited them the most. In their survey of tax records, Piketty and Saez (2007) find such redistributive effects of corporate and estate tax cuts across different income groups. Figure 6 shows the average effective tax rates by income for 1970 and 2004 as reported in their paper.³ The average tax rate for all taxpayers was 23.4% in 1970 and 23.3% in 2004. The average tax rate remained similar for

³Note that corporate and estate taxes paid do not appear on individual income tax returns. Therefore, Piketty and Saez (2007) impute these taxes to different income groups.

Figure 5: The Estate Tax Schedule, 1960 and 2010



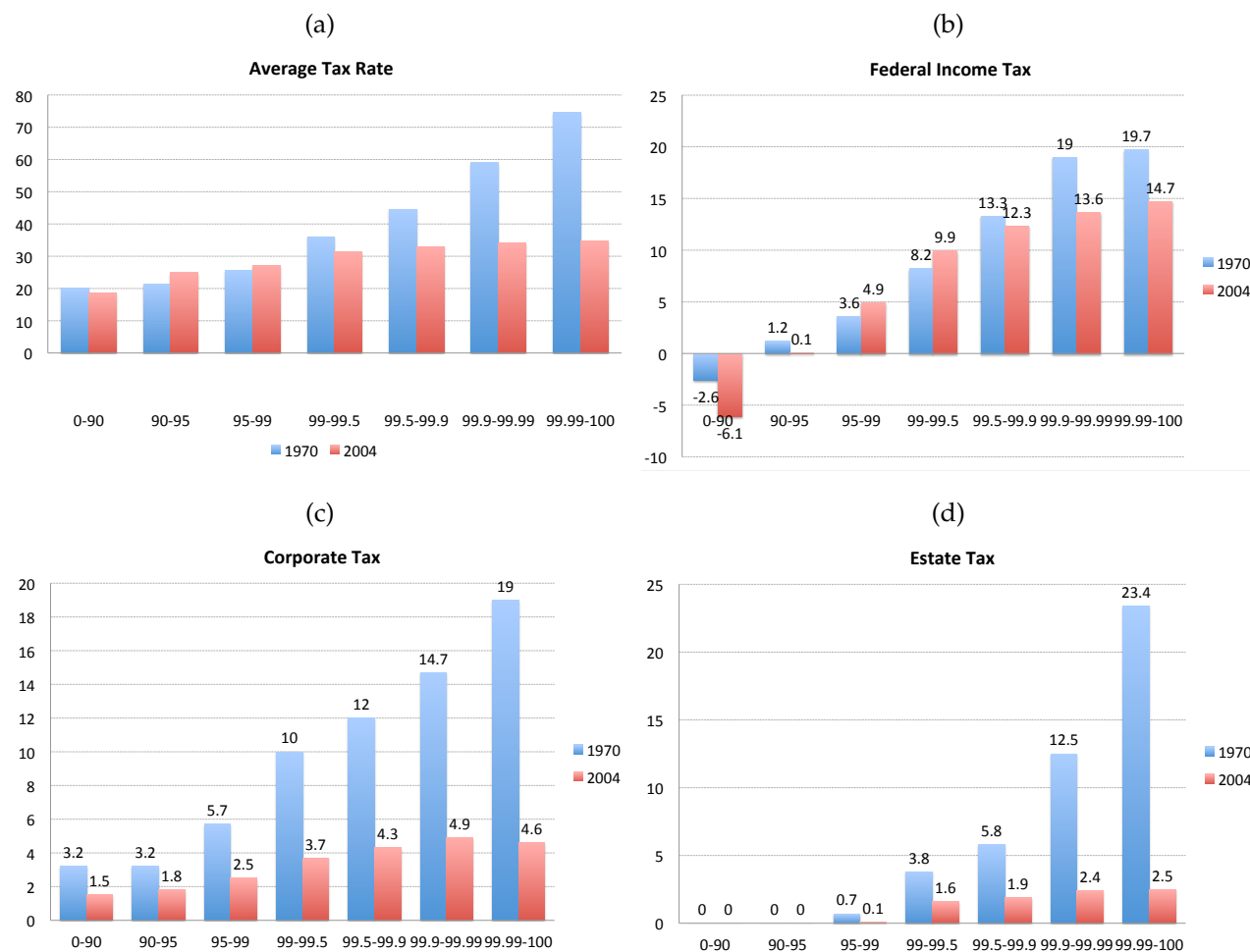
the bottom 99% of the income distribution, while it decreased substantially for all groups in the top 1% category. The magnitude of the drop in average tax rates varies between 4.8 percentage points for those between 99th and 99.5th percentiles and 39.9 percentage points for the top 0.01 percent.

The main source of the reduction came from lower taxes on corporate income and transfer of estates. The reductions from these two sources add up to a 8.5 percent decline in the average tax rate applied to incomes between 99th and 99.5th percentiles and a 35.3 percent decline for the top 0.01 percent. Despite the remarkable decline in the statutory marginal tax rates applied to highest income earners, changes in the personal income tax code contributed little to the decline of the tax progressivity. This is because the very high rates, such as the 90% top statutory marginal tax rate, were paid by only a handful of households. Panel (b) in Figure 6 shows that the decline in the individual income tax on top groups was much more modest, and concerned only the top 0.5% of the income distribution.

3 Model

Our analysis requires a model featuring income and wealth heterogeneity and retirement. We therefore employ a modified version of the neoclassical dynamic stochastic general equilibrium model with uninsurable idiosyncratic income risk (Aiyagari, 1994; Bewley, 1986; Huggett, 1993), combined with a demographic structure that closely resem-

Figure 6: Average Federal Tax Rates by Income Groups



Note: The data for tax rates come from Piketty and Saez (2007).

bles neda, Díaz-Giménez, and Ríos-Rull (2003). In this economy, we include a broad set of taxes and social security, modeled to closely reflect how these institutions operate in practice.

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. Retirees do not work and receive a fixed social security benefit $\omega(z, \mathcal{R})$, described in detail below, which depends on their pre-retirement labor skill.

Private income from labor, savings and social security, corporate income and estates are subject to a detailed tax system, outlined below. Consumption is subject to a proportional sales tax. The government uses tax revenue to finance an exogenous stream of expenditure 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-period 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. The Bellman equation for a consumer's problem then is

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

subject to

$$\begin{aligned} c(1 + \tau_s) + x &= y^d(wzh, rk, \omega(z, \mathcal{R})) + k, \\ k' &= x - E(x, \mathcal{R}, \mathcal{R}'), \\ \Gamma' &= H(\Gamma), \end{aligned}$$

where the expectation is taken over retirement and survival risk and skill transition risk, for both survivors and entrants. $E(x, \mathcal{R}, \mathcal{R}')$ 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 $\omega(z, \mathcal{R})$.

The representative firm produces output Y using aggregate capital K and effective labor N . Its 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 saving and labor supply, $x(k, z, \mathcal{R}; \Gamma)$ 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 policy functions $x(k, z, \mathcal{R}; \Gamma)$ and $h(k, z, \mathcal{R}; \Gamma)$.
2. Factor demands are given by the following inverse 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:

$$K' = (1 - M_1) \int x(k, z, 0; \Gamma) d\Gamma_0(k, z) + M_1 \int [x(k, z, 1; \Gamma) - \mu_d E(x, 1, 0)] d\Gamma_1(k, z)$$

$$N = \int zh(k, z, \mathcal{R}; \Gamma) d\Gamma(k, z).$$

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

5. The government budget is balanced:

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

$$+ \tau_s \int [y^d(\cdot) + k - x(\cdot)] d\Gamma(k, z).$$

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

4 Calibration – preliminary

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 1960. We then introduce changes in the tax system, in social security, and in the distribution of labor productivity observed in the U.S. since 1960 to analyze the relative role of tax cuts in understanding rising economic inequality. In doing so, we treat both 1960 and 2010 as stationary states.

The calibration of the 1960 economy is broadly consistent with the standard for quantitative models with idiosyncratic labor income risk. However, we make two modifications in the spirit of neda, Díaz-Giménez, and Ríos-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 levels across generations.

4.1 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 4.1%, the annual depreciation rate is set to 7.9%, which ensures that the ratio of capital stock to aggregate income in 1960 is 3.

4.2 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 $\{z_1, \dots, z_4\}$ 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.⁴ 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 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, $\{z_1, \dots, z_4\}$, and

⁴The 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.

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 0.52 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 1960. In particular we target the top 0.5 and 1 percent concentration ratios and the Gini coefficients of inequality for income and wealth.

4.3 Tax System

The tax system consists of personal income taxes levied on capital and labor earnings, sales taxes, corporate income 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.⁵ We set $\tau_c = 49\%$, which is the average marginal tax rate on corporate profits in 1960 as reported by Gravelle (2004) 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 .⁶ We then choose d_c such that the share of corporate tax revenue in GDP is 3.8% as measured in the data for 1960.

To obtain the federal income tax base, or adjusted gross income (AGI), we take personal income net of corporate income, subtract employer contributions to social security, and add social security benefits. Social security contributions are levied at a payroll tax rate τ_p , apply to earnings up to a cap of p , and are borne to equal parts by the employee and the employer. Therefore, adjusted gross income y_{agi} is given by

$$y_{agi} = wz h - \min\{wzh, p\}\tau_p/2 + \min(rk, d_c) + \omega(z, \mathcal{R}).$$

[Note: current version of quantitative results have no payroll tax, social security is financed by income taxes.]

⁵As a result, corporate income taxes reduce the tax base for personal income tax.

⁶Only about 20% of U.S. households hold stocks or mutual funds directly (Heaton and Lucas 2000, Bover 2010).

Personal income taxes apply to adjusted gross income. They are modeled after the current U.S. income tax system, which can be approximated by a log-linear form for after-tax income. In addition, we assume that the top marginal tax rate is bounded at $\tau_{\max}$, like in the actual tax system and unlike in the pure log-linear expression. Let the level of income up to which the log-linear system applies be $y_b(\tau_{\max})$. Beyond that, the top rate of $\tau_{\max}$ applies. For 2010, we set $\tau_{\max}$ to 0.35. For 1960, we assume that it is not binding. (The top marginal tax rate generated by the model for that year is around 45%.)

Then, personal income taxes are given by

$$y_{agi} - \lambda [\min(y_{agi}, y_b)]^{1-\tau_l} - (1 - \tau_{\max}) \max(y_{agi} - y_b, 0).$$

The power parameter $\tau_l \leq 1$ controls the degree of progressivity of the tax system, while λ adjusts to meet the government's budget requirement. $\tau_l = 0$ implies a proportional (or flat) tax system. When $\tau_l = 1$, all income is pooled, and redistributed equally among agents. For values of τ_l between zero and one, the tax system is progressive.⁷ See Guner, Kaygusuz and Ventura (2013), Heathcote, Storesletten and Violante (2014) and Bakış, Kaymak and Poschke (2013) for evidence on the fit of this function. Here, we set the progressivity of the personal income tax system in 1960, τ_l , to 0.08. We choose λ to balance the government's budget.

One benefit 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.

Combining all these components, disposable income is the sum of after-tax personal income and corporate income, minus payroll taxes paid by employees, plus transfers:

$$y^d = \lambda [\min(y_{agi}, y_b)]^{1-\tau_l} + (1 - \tau_{\max}) \max(y_{agi} - y_b, 0) + (1 - \tau_c) \max(rk - d_c, 0) - \min(wzh, p) \tau_p / 2 + T. \quad (2)$$

The symmetric treatment of capital and labor income in (2) is in line with the U.S. tax code. Also note that retirees are still subject to federal income taxes on their pension payments and capital earnings.

⁷For income below y_b , the average income tax rate is $1 - \lambda y^{-\tau_l}$, which increases in y if $\tau_l > 0$.

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 5. We do so using statutory estate tax rates and the corresponding brackets reported by the IRS. To obtain comparability across years when changing this function in the following analysis, we normalize the thresholds for estate brackets by average wealth in each year.

The government uses the tax revenue to finance exogenous expenditures and transfers. The expenditures are set to yield a sum of expenditure and transfers of 17% of GDP, as observed in the data. In the data, transfers to persons in 1960 represent 4.5% of GDP, of which 2.5% is destined to the elderly in the form of pension 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 , accordingly, to match receipts per person. Social security benefits are described next.

4.4 Social security

We model transfer payments to retirees as consisting of two components: one component that is related to past income and represents the “primary insurance amount” of social security, and another component that is common across retirees and represents assistance payments (common in 1960) and Medicare. We obtain the former by multiplying an individual-specific replacement rate with the average hourly wage. The replacement rate is a function of past earnings. Its determination is depicted in Figure 7. It consists in a piecewise linear schedule with up to two kinks, labelled b_1 and b_2 , and a cap $\bar{\omega}$. We take information on the cap, the kinks, and on the replacement rates applying between them, ψ_1 to ψ_3 , from the Social Security Administration. The measure of past earnings used by the Social Security Administration is “Average Indexed Monthly Earnings” (AIME); a weighted average over salaries of the past 35 years. For reasons of tractability, we compute a retiree’s replacement rate using earnings of a comparable workers, i.e. somebody with equal productivity and wealth.

The common component is modelled as a common amount T_R that accrues to all retirees. We obtain it by matching the sum of assistance payments and Medicare expenditure per retiree. In the data, this expenditure amounts to 1% of GDP in 1960 (only assistance, no Medicare), and to 3.5% (mostly Medicare) in 2010.

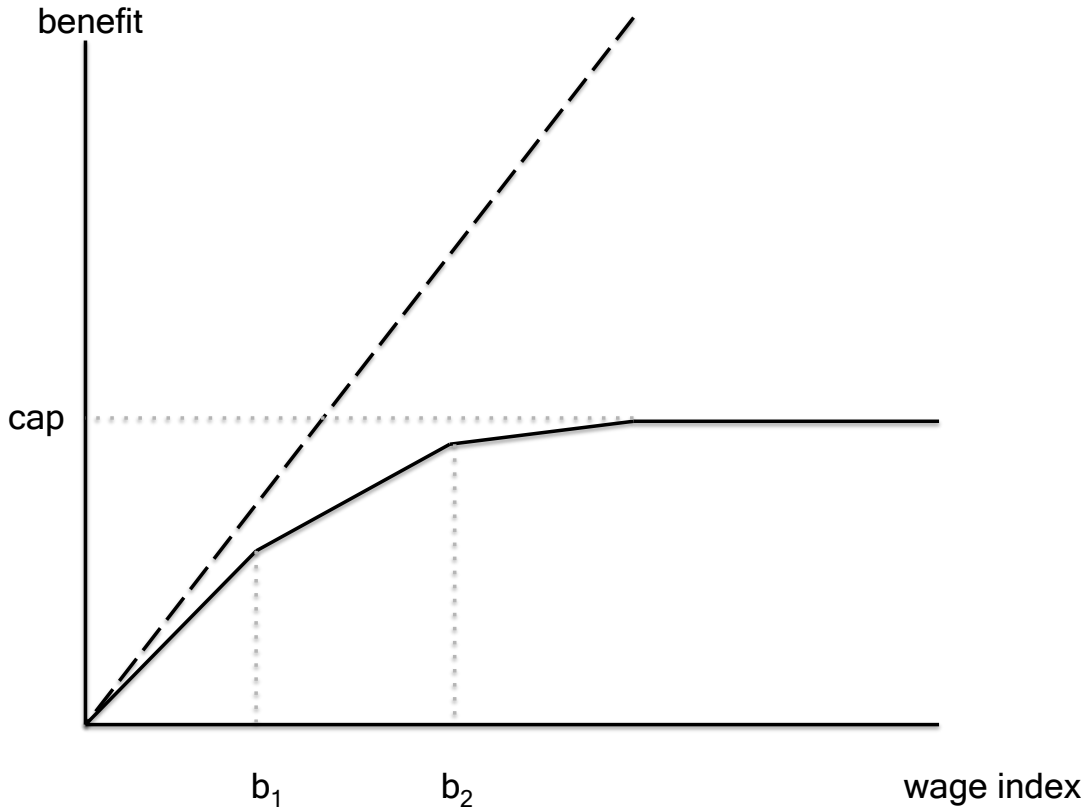


Figure 7: Social security benefits

4.5 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 4.1%. 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 34% of their time endowment to work.

The elasticity intertemporal 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.

Table 1 summarizes the calibration of the model for the 1960 economy.

Table 1: Calibration of the model parameters for 1960

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	Author's Estimates	
$\tau_{\max}$		not binding in 1960	
τ_c	0.49	Marginal Corporate Tax Rate, Gravelle (2004)	
τ_e		Actual Estate Tax Schedule	
γ	0.108	$G/Y = 0.17$	
T/Y	0.02	NIPA	
Social Security			
b_1	0	Social Security Administration	
b_2	0.214		
ψ_1	1		
ψ_2	0.4		
ψ_3	0.1		
$\bar{\omega}$	0.171		
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	0.041
θ	12	mean hours	0.34
ϵ	1.67	Frisch elasticity	0.6
T_R	0.07	(Pension assistance+Medicare)/GDP	1%
d_c/r	$0.47 \times K$	Corporate tax revenue/GDP	3.8%

5 Calibration Results for the 1960 economy – preliminary

In this section we overview the characteristics of the 1960 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%.⁸ These figures imply a considerable degree of persistence of having a high 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 80%.

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 6 times the average. The top state z_6 alone corresponds to 0.08% of the workforce, with a productivity level that is 57 times the average. When households reach these states, they also work about 20% 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 highly concentrated as observed in the data.

Table 2 shows the distributions of total income, wealth and labor income for the 1960 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 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 Keister and Moller (2000) and are based on 1962 Survey of the Financial Characteristics of Consumers (SFCC). The model closely approximates the distributions of income and wealth. While the earnings distribution

⁸The full set of calibrated values for the transition matrices are reported in the appendix.

Table 2: Distribution of Income and Wealth in 1960

	Top Percentile							Gini
	0.5%	1%	5%	10%	20%	40%	60%	
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	0.61	0.78	0.90	0.97	0.73
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	0.75	0.89	0.33
Earnings Share (Data)	0.05	0.07	0.20	0.33				0.34
Earnings Share (Model)	0.09	0.11	0.26	0.43				0.32

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.

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.⁹ In line with this, the model slightly overstates the share of labor income in the top 1% incomes, at 71% versus 60% in the data (Piketty and Saez, 2003), but is accurate for the top 10%, at 80%, and below.

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 1960. In their survey of tax records, Piketty and Saez (2007) report the

⁹Income 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 3: Average Tax Rates by Income Group in 1960

	Corporate Tax			Estate Tax			Income Tax		
	1%	99%	R/Y	1%	99%	R/Y	1%	99%	R/Y
Data	14.4	5.1	3.8	6.0	0.0	0.3	24.0	13.8	10.6
Model	14.4	4.6	4.6	3.1	0.1	0.3	22.6	10.6	9.6

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

average tax rates for different tax categories for top income groups. In Table 3, 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. [Still need to adjust d_c .] 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 is also close to that in the data, although this is not a calibration target. The model matches the fact that the 99% pay essentially no estate taxes, but understates the estate tax paid by the top 1% of the income distribution. We think that the difference might stem from the way estate taxes are imputed to income groups in Piketty and Saez (2007), which likely overshoots the actual figure in the data.¹⁰ The fact that the model does not overstate top estate tax rates and provides a good approximation of aggregate revenue indicates that the use of the statutory tax schedule provides a good representation of the estate tax system, even if it abstracts from certain deductions, deferrals and methods of tax avoidance. Finally, the progressivity of the personal income tax system chosen for the calibration closely reflects the distribution of the income tax burden.

Overall, the calibration of the parameters seems reasonable, as the model does a good job of capturing the salient features of the 1960 economy. In particular, the distributions of income, wealth and the tax burden among households is consistent with the empirical facts of the time. We find this encouraging as it indicates that the model provides an appropriate framework to study the macroeconomic implications of the changes in the

¹⁰Since estate taxes are filed separately, relating them to income tax records is not straightforward. The working assumption in Piketty and Saez (2007) is a perfect rank correlation between the size of the estate and the income of the decedents, which represents an upper bound for the estate tax paid by top income groups.

tax system, which we turn to next.

6 Changes in Institutions and Technology and the Evolution of Inequality – Steady State Analysis

In this section, we analyze the effect of changes in the tax policy, in social security, and the distribution of labor productivity on economic inequality. We change all tax schemes in line with the data, and expand social security. We also increase the variance of labor productivity, mimicking skill-biased technical change over the period 1960 to 2010.

We modify the tax system as follows in order to reflect the situation in 2010. First, we decrease the corporate income tax rate from 49% to 23.6%, which is the average marginal tax rate on corporations reported by Gravelle (2014) for 2010. Secondly, we change the estate tax schedule to represent the 2010 statutory rates and brackets relative to average wealth in 2010. Thirdly, we reduce the top marginal income tax rate to 35%. This is close to statutory top marginal federal income tax rates reported by Guner, Kaygusuz, and Ventura (2014). Figures for effective top rates reported by the same authors are a bit lower at 25 to 30%. Yet, it should be noted that these rates exclude state income taxes. In the main analysis, we do not change the progressivity of the tax system. We conduct robustness checks where we raise τ_l to 0.166, as estimated by Bakis, Kaymak, and Poschke (2012). Recall that average tax rates adjust to balance the government's budget.

The expansion of transfers had two important components: more generous pensions, and the introduction and expansion of Medicare. The former is reflected in an increase in replacement rates, and a large increase in the cap from 0.17 to 0.57 times average wages. (See Table 4 for details.) This expansion was financed with an increase in payroll taxes. [In the current version of our results, which still does not have payroll taxes, it is financed with an increase in λ , i.e. an across the board increase in average personal income taxes.] The increase in generosity is clearly visible in Figure 8, which depicts replacement rates as a function of earnings for 1960 and 2010. The increase in transfers unrelated to income, such as Medicare, is captured by an increase in T_R from 0.07 to 0.18. This results in payments to retirees in line with aggregate expenditure on this component of 3.5% of GDP in 2010. Taken together, payments to retirees are consistent with aggregate expenditure on pensions and medicare of 8% of GDP.

The third important change that occurred over the period under consideration are changes in technology, and notably in the return to skill. We capture the technological

Table 4: The tax system and social security, 1960 and 2010

	1960	2010
<i>Taxes</i>		
τ_l	0.08	0.08
$\tau_{\max}$	not binding	0.35
τ_c	0.49	0.236
τ_e	see Figure 5	
<i>Social Security</i>		
b_1	0	0.2
b_2	0.214	1.22
ψ_1	1	0.9
ψ_2	0.4	0.32
ψ_3	0.1	0.15
$\bar{\omega}$	0.171	0.57
T_R	0.07	0.18

changes that lead to a higher wage inequality by raising the variance of the labor productivity process to match the rise in the household earnings variance in equilibrium. In doing so, we maintain a constant average labor productivity. This requires a 21.3% increase in the standard deviation of the process and a 0.187 log-points decline in the median.

Table 5 reports the distributions of earnings, income and wealth associated with the steady-state of the new economy. We compare these numbers with the corresponding figures in 2010. The distributions implied by the model closely replicate the observed values in 2010. Because our current preliminary parameterization overstates the earnings variance in the new economy, the model even overshoots wealth concentration in the data. Another possible explanation for this is that some of the changes in top income inequality as well as some of the changes in the tax system, especially regarding estate taxes, are fairly recent. As a result, it is possible that in the data, 2010 is along a transition path to a long-run equilibrium with more severe wealth inequality than currently observed.

In the results just presented, social security, taxes and wage inequality were all different from 1960. Together, these changes in institutions and technology do a good job of accounting for changes in inequality observed over the 50 years from 1960 to 2010. Next, we ask how much of the change can be attributed to each individual feature. To answer

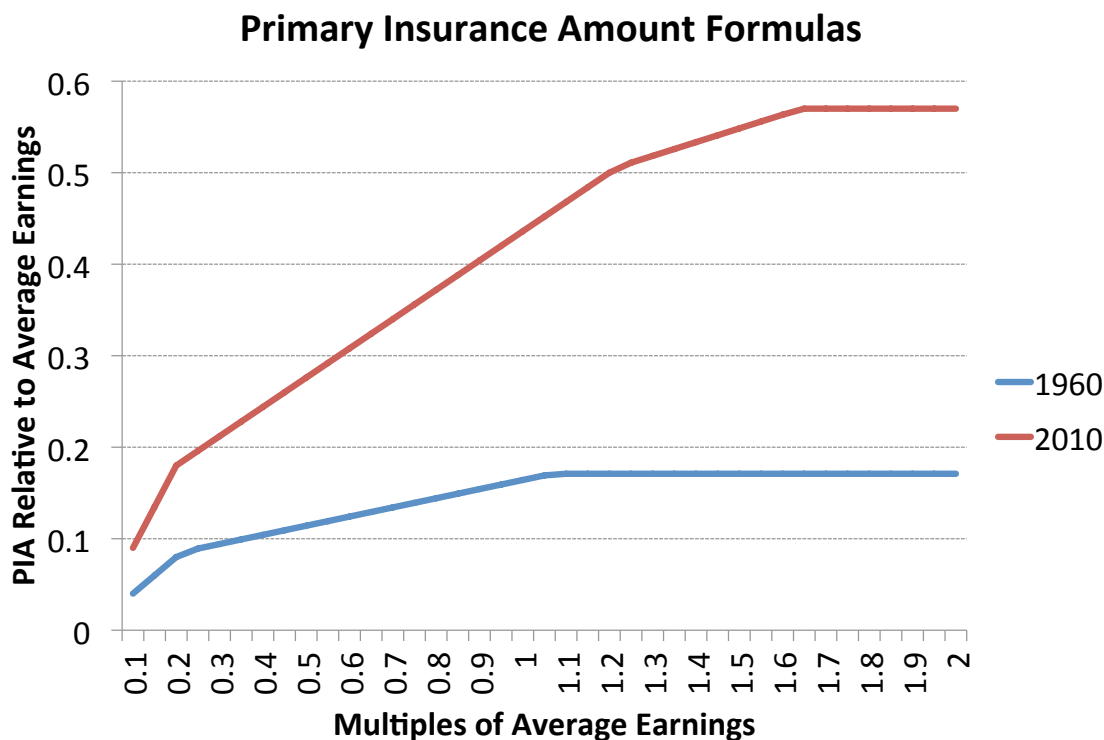


Figure 8: caption

this question, we take the 1960 model economy, and change each element individually, one by one.¹¹ Table 6 shows how inequality in the model changes as a function of each feature of the model economy that changes between 1960 and 2010.

6.1 Transfers, saving behavior, and inequality

First of all, both changes in the social security system reduce income inequality below the top 1%, as evidenced by a decline in the top 10% income share and in the Gini coefficient of the income distribution. This change is driven by an increase in the relative income of retirees, whose income share increases from 7.5% to 15.5% due to more generous social security. (Not shown in the table.) The wealth share of retirees also increases. Income inequality among workers, in contrast, does not change much. Like the distribution of income, the distributions of disposable income and of consumption both become more equal.

¹¹An alternative approach would be to take the 2010 economy, and undo each change individually, one by one. This approach yields qualitatively very similar results. Below, we comment on some differences.

Table 5: Income and Wealth Inequality in 2010

	Top Percentile							Gini
	0.5%	1%	5%	10%	20%	40%	60%	
Wealth Share (Data)	0.31	0.40	n/a	0.74	0.83	0.95	0.99	0.82
Wealth Share (Model)	0.36	0.45	n/a	0.82	0.97	1.00	1.00	0.90
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	0.31	0.47	0.54	0.75	0.86	0.41
Earnings Share (Data)	0.12	0.16	0.33	0.47				0.42
Earnings Share (Model)	0.17	0.19	0.35	0.53				0.41

Although the top 1% income share is unchanged and the top 10% income share declines, the top 1% and 10% wealth shares both increase. Although the top income and wealth groups are not exactly identical, this pattern suggests that the changes in the wealth distribution are driven not so much by changes in the distribution of income, but rather by changes in saving rates, to which we turn next.

Table 7 shows saving propensities and a measure of the generosity of social security for three wealth groups: the top 1%, the top 10%, and the bottom 90%.¹² The saving propensity is the propensity to save out of total after tax resources, defined as $x / (y^d + k)$. (If no estate tax is due in the transition to the next period, this is identical to $k' / (y^d + k)$.) The social security replacement rate is computed, for all workers in a wealth group, as the ratio of total pension benefits due in the next period, should they retire, over total income. Due to the combination of the progressivity of the social security benefit schedule and the positive correlation between income and wealth, the social security replacement rate is much higher for less wealth households. It is also clear that wealthier households save substantially more. Since on average they have high income, all three savings motives present in the model – life-cycle, precautionary, and bequest – are stronger for them.

The expansion of social security makes benefits more generous for all groups, but particularly so for the bottom 90%. Comparing stationary equilibria, the replacement rate for the top 1% wealthiest workers doubles, but remains small; social security does not even

¹²Note that for conciseness and simplicity, the discussion in the following few paragraphs conflates income and wealth differences to some extent. This is inaccurate to the extent that the correlation between these two variables is high but not perfect. However, all patterns reported in the table and the following two figures are very similar when grouping households by income instead of wealth.

Table 6: The effects of changing institutions and wage inequality on the distribution of income and wealth

	Wealth distribution			Income distribution			c	y^d	Retiree wealth share
	Top 1% share	Top 10% share	Gini	Top 1% share	Top 10% share	Gini (all)	Gini (workers)	Gini	Retiree wealth share
benchmark (1960)	0.262	0.610	0.727	0.112	0.412	0.501	0.333	0.402	0.440
<i>difference to benchmark (percentage points):</i>									
more generous social security									
... only benefit component	3.9	4.0	2.6	0.1	-1.3	-3.9	0.6	-3.0	-4.1
... only fixed component T_R	2.6	3.5	3.7	0.1	-0.7	-2.9	0.6	-2.3	-3.1
... both components	4.4	3.4	1.6	-0.2	-2.4	-6.1	0.7	-4.7	-6.1
lower taxes									
... lower corporate income taxes	-0.3	2.1	3.6	-0.4	-0.6	-0.2	-0.2	0.7	0.9
... 2010 estate tax schedule	-0.8	2.3	2.5	-0.2	0.6	0.2	0.2	0.1	0.2
... lower top marginal tax rate	1.8	0.9	0.9	0.3	0.4	0.2	0.2	0.3	0.3
higher wage inequality	14.3	10.8	9.1	7.5	5.9	8.0	7.6	6.8	6.7
all changes (2010)	18.4	20.8	17.5	6.2	5.4	2.3	8.0	3.5	2.5
									0.151
									0.5
									0.3
									0.0
									0.2
									3.7

Table 7: The effects of changing institutions and wage inequality on saving, by wealth group

	Saving rates by wealth			Transfer replacement rates by wealth group		
	Top 1%	Top 10%	Bottom 90%	Top 1%	Top 10%	Bottom 90%
benchmark (1960)	0.942	0.895	0.705	0.027	0.070	0.291
<i>difference to benchmark (percentage points):</i>						
more generous social security						
... only benefit component	0.1	0.0	-4.5	1.9	8.6	23.5
... only fixed component T_R	0.0	0.2	-3.6	0.8	3.7	22.5
... both components	0.1	0.0	-5.2	3.1	12.8	46.5
lower taxes						
... lower corporate income taxes	0.2	1.0	1.3	0.3	0.0	1.8
... 2010 estate tax schedule	0.1	0.7	-0.7	0.1	0.0	-1.5
... lower top marginal tax rate	0.1	0.2	-0.2	0.3	0.2	0.2
higher wage inequality	0.4	0.9	-2.2	-0.7	-1.4	5.0
all changes (2010)	0.6	2.5	-12.6	6.4	12.7	43.0

replace 10% of income for this group. For the bottom 90%, in contrast, the replacement rate almost triples, and goes from replacing about one quarter to three quarters of income in that group. The change for the top 10% lies in between. As a consequence of these changes, the retirement saving motive for the bottom 90% is significantly weakened, and the saving propensity of this group declines by five percentage points, while it hardly changes for the top 1% and 10%.

The expansion of transfers goes along with substantial general equilibrium effects, as shown in Table 8. First, since households that can count on larger transfers in retirement reduce their saving, the capital stock declines. This tends to increase the interest rate and to reduce the wage rate by up to 5%. As a consequence, hours and the aggregate labor input decline slightly. Output then contracts mostly as a consequence of the smaller capital stock. As the latter implies that less investment is required, consumption declines less than output, by 3% overall. Finally, the overall burden of income taxes increases, with a reduction in λ of around 8%, as more revenue is required for financing increased transfer expenditure.

These general equilibrium effect attenuate the response of saving to increased trans-

Table 8: The effects of changing institutions and wage inequality on aggregate outcomes

	K	N	Y	r	w	C	average hours	λ
benchmark (1960)	29.9	5.65	10.3	0.045	1.17	7.93	0.344	1.06
<i>relative to benchmark (benchmark = 100):</i>								
more generous social security								
... only benefit component	89.7	99.6	95.9	119.1	96.3	97.8	99.6	94.9
... only fixed component T_R	92.7	99.8	97.2	113.7	97.4	98.5	99.9	96.9
... both components	86.2	99.4	94.4	125.1	95.0	96.9	99.3	91.8
lower taxes								
... lower corporate income taxes	112.8	100.0	104.4	77.3	104.4	101.9	100.0	95.9
... 2010 estate tax schedule	104.1	100.2	101.6	92.9	101.4	100.8	100.1	99.6
... lower top marginal tax rate	101.3	100.2	100.6	98.4	100.4	100.4	100.1	99.7
higher wage inequality	118.9	103.3	108.7	75.2	105.2	105.6	100.2	102.5
all changes (2010)	120.4	103.1	109.0	71.0	105.8	105.6	99.6	90.1

fers, as illustrated in Figure 9. This figure shows a decomposition of changes in the saving rate in response to the expansion of social security into two effects: the change in saving rates in response to more generous social security, keeping prices and the entire tax schedule, including λ , at the benchmark levels (direct effect, solid line), and the change in saving rates induced by price changes generated by the introduction of social security, keeping social security at the benchmark level (general equilibrium effect, broken line). The sum of the two effects approximately equals the entire effect of increasing the generosity of social security in general equilibrium, as the further effect due to changing λ is very small. As a reminder, the figure also shows the change in the replacement rate for each group (line with diamonds, right axis). It is clear that the partial equilibrium effect of expanding social security on saving rates is very large; the saving rate of the bottom 90% drops by almost 20 percentage points, from around 70 to around 50%. The saving propensity of the top 10% declines slightly, while that of the top 1% remains essentially unchanged. In general equilibrium, the reduction in saving leads to an increase in the interest rate, from 4.5 to 5.6%. (See also Table 8 below.) This in turn affects saving incentives, and attenuates the decline of the saving propensity of the bottom 90%. While higher r also affects saving of higher-wealth groups, this effect is smaller for them, as the income effect of the price change is larger for groups that derive more of their income from capital. The total effect of expanding social security on saving of the bottom 90% is strongly negative, as seen in Table 7, since the negative direct effect clearly outweighs the positive general equilibrium effect.

The expansion of transfer payments had two components: a more generous social security benefit schedule, and larger payments that are independent of past income. Figure 10 shows the effect of each component on saving separately, as well as the implied effect of each component on the replacement rate. Again, the figure shows the effects of social security keeping prices fixed at the benchmark level, as well as the effect of the price change resulting from the expansion of social security (both components). It is evident that both components of social security induce a strong decline in saving among the bottom 90%. However, given that the change in the benefit schedule had a larger effect on replacement rates, its effect on saving rates is also larger. In addition to this, since the change in benefits, unlike the fixed component, was skewed towards the poor, its effect varies more across wealth groups.

To summarize, we find that the expansion of social security contributed significantly to increasing wealth inequality by reducing saving propensities among the bottom 90%

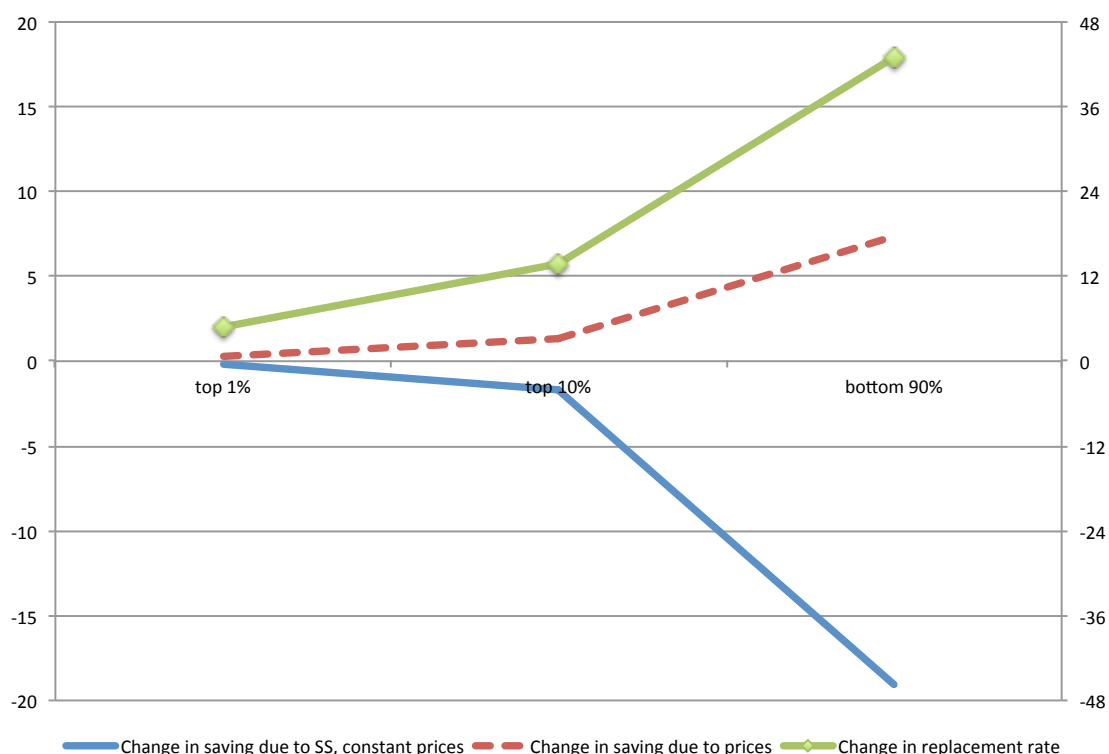


Figure 9: Changes in saving propensities in response to expansion of transfers, by wealth group

of the wealth distribution. Given only small changes in saving at the top of the wealth distribution, this results in a lower wealth share of the bottom 90%. These changes in saving are attributable both to changes in the social security benefit schedule and in the expansion of fixed payments, with a slightly larger role for the former. Finally, the effect of the social security expansion on saving would be even stronger were it not for a counteracting general equilibrium effect.

6.2 Tax changes, wage inequality, and the distribution of wealth

The effect of tax changes and wage inequality on the wealth distribution closely parallels those found in Kaymak and Poschke (2014). We therefore discuss each element briefly.

As shown in Table 6, lower corporate income and estate taxes do not affect the distribution of income. Therefore, they affect the wealth distribution through their effect on saving rates.

Changes in saving are shown in Table 7 and in 11, which display changes in sav-

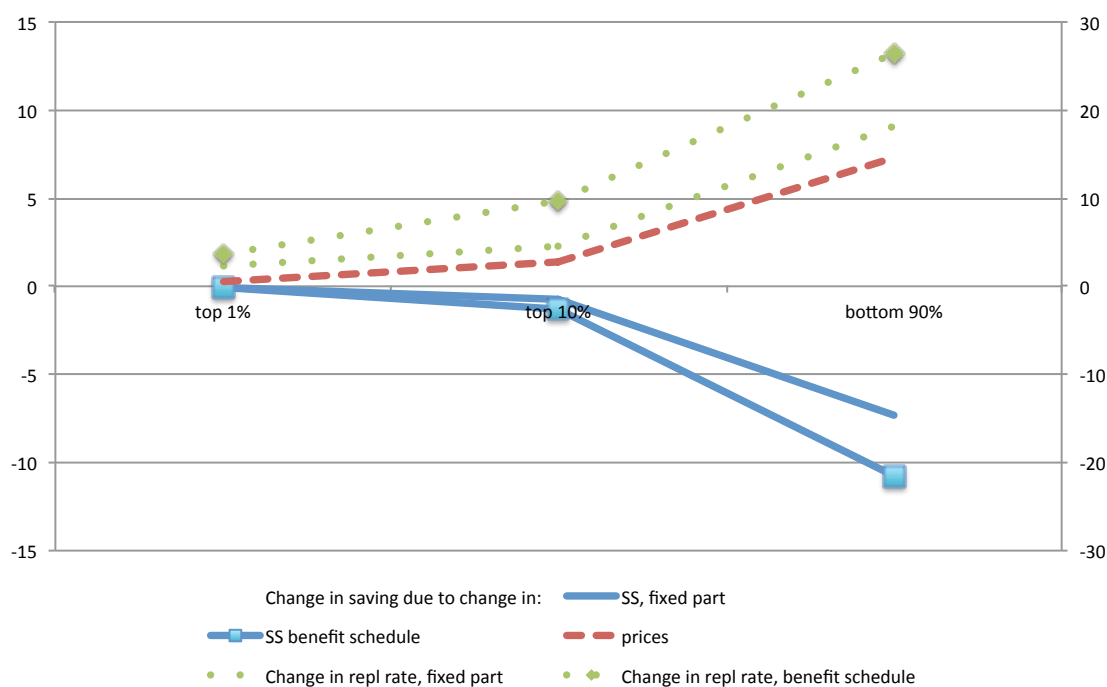
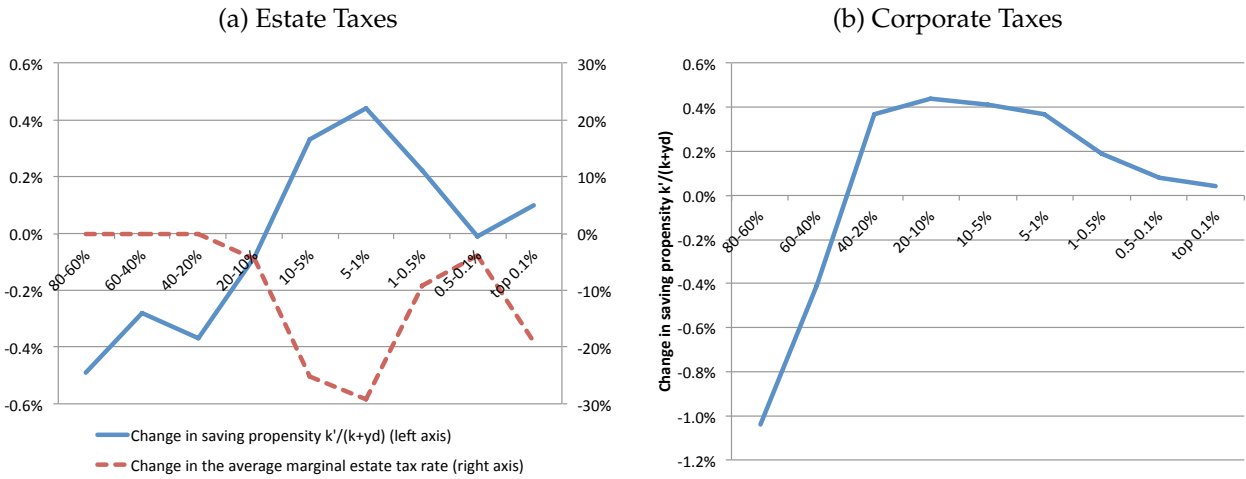


Figure 10: Changes in saving propensities in response to expansion of transfers, by wealth group and type of transfer

ing rates and in effective tax rates across the wealth distribution. The figure also shows changes in the effective marginal estate tax rate for different parts of the wealth distribution. Changes in the estate tax system can be captured by two key components: a much larger exemption, and much lower top rates. The larger exemption mostly benefits groups just outside the top 1% of the wealth distribution. Lower top rates benefit very wealthy households, albeit to a moderate extent: while effective estate tax rates decline for the top 0.3% of the wealth distribution, the largest declines are realized for marginal rates on very large estates, which only affect a small fraction of wealth transfers, even for the wealthy. As a consequence, changes in the estate tax system mostly affect saving behavior of the 90-99% group. Their wealth increases for two reasons: first, their wealth transfers are subject to lower taxes, and second, they increase their saving in response to the lower tax rate.

The reduction in corporate income taxes has a similar effect. Changes in saving behavior in response to it is shown in panel (b) of Figure 11. First of all, since low-wealth households are not exposed to this tax, their saving behavior only reacts to the tax cut via general equilibrium effects. For those who are affected, a stronger substitution effect

Figure 11: Saving Propensity and Marginal Tax Rates



Note.— The figure represents reactions to changes in the estate tax system and the corporate tax rate for different groups of the wealth distribution (horizontal axis).

relative to the income effect leads to higher saving propensities. However, as the income effect is larger for households that receive a larger fraction of their income from capital, the saving rate increases most for households in percentiles 70-95 of the wealth distribution, and changes very little in the top 1%. As a consequence, wealth of the top 1-10% of the wealth distribution expands relative to the rest of the distribution, implying that the shares of the top 1% and the bottom 90% decline.

While changes in the wealth distribution in response to changes in corporate income and estate taxes are driven by the saving reaction, the pattern is essentially the reverse for a decline in the top marginal income tax rate. This change leads to a slight increase in top income shares, as high-productivity agents work more. Saving rates change very little. As a consequence, the wealth share of top wealth groups increases in line with the increase in their income shares.

All three tax changes encourage capital accumulation, either by directly increasing incentives to save (reduction in capital income taxation) or by increasing resources available to agents with high propensities to save (lower top marginal tax rate). As a result, all of them lead to lower interest rates and higher wages. The increased capital stock also implies larger output. Since investment also needs to increase to maintain the larger capital stock, aggregate consumption increases less than output, by 0.4 to 2%, depending on

the exercise. To evaluate welfare, it would be necessary to evaluate whether this increase in output is sufficient to compensate for higher consumption inequality. The evaluation would depend on the degree of inequality aversion in the social welfare function. In addition, knowing about steady state outcomes is not sufficient for making this evaluation, as accumulating additional capital has costs along the transition. Bakis, Kaymak, and Poschke (2012) show that for optimal progressivity of income taxes, results may differ substantially depending on the welfare weights of present and future generations.

Finally, changes in wage inequality strongly amplify income differences. They strongly increase the income shares of the top 1%. The share of the top 10% increases, but less than that of the top 1%, indicating that the income share of percentiles 90-99 actually declines slightly. Due to the larger earnings variance throughout the distribution, the Gini coefficient of income among workers increases strongly, in turn driving up the overall income Gini coefficient. Inequality in disposable income and consumption increase slightly less than pre-tax income inequality.

Changes in wage inequality have further small effects on saving behavior. Since overall income dispersion increases, the precautionary saving motive for high-income earners becomes stronger, so that saving propensities at the top of the distribution increase. Since productivities of the least productive households decline with the larger spread in z , saving propensities of the bottom 90% fall slightly. Due to the increase in saving rates, top wealth shares rise by substantially more than corresponding top income shares.

Aggregate variables are also affected. While average hours hardly change, the aggregate labor input increases substantially, as the labor input of high-productivity workers relative to low-productivity ones increases due to the higher productivity spread. A larger labor input increases the marginal product of capital and encourages capital accumulation. The larger productivity spread and a shift of income to households with a high propensity to save imply further increases in saving, implying that overall, the capital stock increases more than the labor input, and the capital-labor ratio increases. Since both inputs increase, output increases, and consumption increases by about 5%.

Comparing the different potential sources of increased wealth inequality, it is clear from Table 6 that, despite the dominant role of changing wage inequality, the expansion of social security also accounts for an important portion. The model generates an increase in the top 1% wealth share of 18 percentage points for all channels combined. The expansion in social security accounts for about a quarter of this. Similarly, the model predicts an

increase in the top 10% wealth share of 21 percentage points, of which about one sixth can be attributed to social security.

The expansion of transfers accounts for a smaller share of the increase in the Gini coefficient of wealth. The reason for this is that larger transfers essentially lead to a substitution of claims on the public sector for private wealth accumulation by low-wealth households. This effect is not present for high-wealth households, for whom transfers are very small compared to income, implying a small saving response. The expansion of transfers thus mainly affects wealth differences between high and low wealth households, and less so within the group of low-wealth households. Moreover, this pattern suggests that while the expansion of transfers leads to higher top wealth shares, the distinction between private wealth accumulation and the accumulation of claims on the public sector is important.

7 Changes in Institutions and Technology and the Evolution of Inequality – from 1960 to 2010

In progress.

8 Conclusion

To be concluded...

A Additional Tables and Figures

Table 9: The Transition Matrix for The Life-cycle Productivity Process

$z_W \backslash z_W$	6.7	19.2	20.5	58.4	61.4	1222
6.7	0.967	0.009	0	0	0.002	0
19.2	0.006	0.970	0	0	0.002	0
20.5	0	0	0.967	0.009	0.002	0
58.4	0	0	0.006	0.970	0.002	0
61.4	0.034	0.034	0.034	0.034	0.826	0.014
1222	0	0	0	0	0.205	0.773

References

- Aguiar, Mark and Mark Bilal. 2011. "Has Consumption Inequality Mirrored Income Inequality?" Mimeo.
- Aiyagari, Rao. 1994. "Uninsured Idiosyncratic Risk and Aggregate Saving." *Quarterly Journal of Economics* 109 (3):659–684.
- Badel, Alejandro and Mark Huggett. 2014. "Taxing Top Earners: A Human Capital Perspective." Federal Reserve Bank of Saint Louis Working Paper.
- Bakis, Ozan, Baris Kaymak, and Markus Poschke. 2012. "On the Optimality of Progressive Income Redistribution." *CIREQ Working Paper* 10-2012.
- 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.
- Cagetti, Marco and Mariacristina de Nardi. 2009. "Estate Taxation, Entrepreneurship, and Wealth." *American Economic Review* 99 (1):85–111.
- Domeij, D. and J. Heathcote. 2004. "On the Distributional Effects of Reducing Capital Taxes." *International Economic Review* 45 (2):523 – 554.
- Gravelle, Jane. 2004. "The Corporate Tax: Where Has It Been and Where Is It Going?" *National Tax Journal* 57 (4):903–923.
- . 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* in press.
- Heathcote, Jonathan, Fabrizio Perri, and Giovanni L 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. 2010. "Redistributive Taxation in a Partial-Insurance Economy." Mimeo.
- . 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.
- Joulfaian, David. 2013. "The Federal Estate Tax: History, Law and Economics." US Department of Treasury - Office of Tax Analysis.
- Kaymak, Baris and Markus Poschke. 2014. "Macroeconomic Implications of Top Income Tax Cuts: 1960 - 2010." *manuscript* .
- 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.
- Kopczuk, W., E. Saez, and J. Song. 2010. "Earnings Inequality and Mobility in the {U}nited {States: Evidence from Social Security Data since 1937. *Quarterly Journal of Economics* 125 (1):91 – 128.
- 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.
- Lopez Danieri, Martin, Nezih Guner, and Gustavo Ventura. 2014. "Heterogeneity and Government Revenues: Higher Taxes at the Top?" CEPR Discussion Paper.
- Mertens, Karel. 2013. "Marginal Tax Rates and Income: New Time Series Evidence." NBER Working Paper.
- neda, A. Casta J. Díaz-Giménez, and J. V. Ríos-Rull. 2003. "Accounting for the U.S. Earnings and Wealth Inequality,." *Journal of Political Economy* 111 (4):818–857.

- 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 and Gabriel Zucman. 2014. "Wealth Inequality in the United States since 1913: Evidence from Capitalized Income Tax Data." *NBER Working Paper* 20625.
- Solon, G. 1999. *Handbook of Labor Economics*, vol. 3, chap. 29. Elsevier Science B. V.
- Wolff, Edward N. 1998. "Recent Trends in the Size Distribution of Household Wealth." *Journal of Economic Perspectives* 12 (3):131–150.