The evolution of wealth inequality over half a century: the role of taxes, transfers and technology*

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Abstract

Over the last 50 years the US tax system went through a striking transformation that reduced the effective tax rates for top income groups and raised transfers to seniors. This paper investigates the macroeconomic repercussions of this change in policy, particularly for the distributions of income, wealth and consumption. Changes in taxes and transfers account for nearly half of the rise in wealth concentration. Nonetheless, their impact on the distributions of income and consumption has been minor due to changes in equilibrium prices and the offsetting effects of tax cuts and transfers on the dispersion of consumption. Results highlight the role of increasing wage dispersion during this period as the main driver of trends in inequality.

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1 Introduction

Over the last 50 years, the US economy experienced a notable increase in income and wealth inequality. The discussions regarding the causes and consequences of these trends are at the forefront of academic and public debate. An important element of the debate has been the relative role of market-based explanations and institutional factors. In this paper, we aim to contribute to this debate by evaluating the impact of changes in the US tax and transfer policy on wealth inequality relative to the role of technological changes that have led to higher wage dispersion during this period.

Following a long secular reduction, wealth became increasingly concentrated during the second half of the 20th century. Using capitalization methods based on extensive data from tax records, Saez and Zucman (2014) report a dramatic increase in wealth concentration since 1970. The share of the wealthiest 1% increased from 27.6% in 1970 to 41.8% in 2012. A similar, but nuanced picture appears in data from Survey of Consumer Finances, where the share of the wealthiest 10% increased from 67% in 1983, the earliest year available, to 75% in 2013.[1]

The US economy went through several institutional and technological changes during this period that could potentially explain the rising wealth dispersion observed in the data. In particular, there were substantial changes in the tax system that reduced taxes on top income earners, an expansion of government transfers, and an significant increase in wage inequality.

The progressivity of the U.S. federal tax system hit a record high during the mid-twentieth century and has declined considerably ever since following a series of reforms that reduced the tax rates applied to top income groups. The decline in the progressivity of the tax system was mainly driven by major reductions in taxes levied on corporations and estates. Over the years, more generous allowances and exemptions, combined with a decline in marginal tax rates, especially those at the top, led to a significant drop in the share of tax revenue collected from corporations and estates. Since the ownership of wealth and financial assets in the US is highly concentrated, these policies disproportionately favored the top wealth and income groups. The redistributive effects of lower corporate and estate taxes were further intensified by a secular decline in the federal income tax rates applied to highest income groups. In their survey of tax records, Piketty

[1] The two data sources disagree on the exact source of the increase in the concentration ratios: the SCF shows that the increase in wealth inequality was driven primarily by those in 90th to 99th percentile of the wealth distribution, therefore excluding the top 1%, while the tax records attribute the higher wealth inequality to the rise in the wealth holdings of the top 0.1% of the distribution (see Kopczuk (2015) for a discussion of different methods and data sources). In our quantitative analysis we utilize the figures in Saez and Zucman (2014) to calibrate our model for 1960, as data are not available in the SCF prior to 1983.

and Saez (2007) report that the average effective tax rate decreased from 45% in 1960 to 33% in 2004 for the top 1% of the income distribution and from 71% to 34% for the top 0.1%, primarily due to cuts in corporate and estate taxes. Meanwhile, the average rate for all taxpayers went up slightly from 20% to 23%, implying an increase in the tax rates applied to other income groups.

However, the changes in tax policy have to be analyzed in connection with the corresponding changes in transfer policy. During the same period, the share of total transfer payments in GDP increased from 4.1% to 11.9%. The rise in transfer spending was driven by two major programs: Social Security and Medicare, both of which target senior citizens. By subsidizing income and healthcare expenditures for the elderly, these programs curb incentives to save for retirement, a major source of wealth accumulation over the life-cycle. Furthermore, since both programs are redistributive by design, they have a stronger effect on the savings of low and middle income groups. By contrast, those at the top of the income distribution have little to gain from these programs. We argue that the redistributive nature of transfer payments was instrumental in curbing wealth accumulation for income groups outside the top 10% and, consequently, amplified wealth concentration in the US.

While changes in both taxes and transfers might have increased the share of wealth held by the wealthiest, distinguishing between the two is crucial for understanding the potential implications of rising wealth inequality for welfare. A less progressive tax system raises the dispersion of disposable income, and, hence, consumption, whereas larger transfers redistribute disposable income, reducing consumption inequality. Whether public policy circles should be alarmed by the rising dispersion in wealth holdings therefore depends critically on its underlying causes.

The changes in the tax and transfer system occurred against a backdrop of changes in production technologies that favor skilled labor, leading to a greater dispersion in labor productivity, and, hence, wages. It is plausible that higher earnings inequality translates into larger consumption and wealth inequality over time. In fact, earnings have become an increasingly important source of income for top groups in recent decades, suggesting that wage dispersion may well be the dominant force behind wealth inequality (Piketty and Saez, 2011). Our aim is, therefore, to compare the effect of changes in policy with the role technological factors played as a driver of wealth dispersion.

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.

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 particularly essential to our purpose as the two tax components account for much of the decline in tax progressivity in the US.

The model parameters are calibrated to replicate the income and wealth distributions in the 1960s, while matching the life-cycle and intergenerational transitions in income. Then we introduce the yearly changes to the tax and transfer policies and to the distribution of labor productivity observed in the US, and compute the resulting long-run equilibrium as well as the associated transitional dynamics. Combined, these changes capture the observed evolution in income and wealth inequality well. To highlight the contribution of each factor separately, we return to the 1960 economy and simulate counterfactual transition paths for economies where different factors are introduced individually or in different combinations. This also allows us to discern potential interactions between changes in institutions and technology.

The results indicate that the changes in the tax and transfer system made a significant contribution to the rise in wealth inequality in the US. Between 1960 and 2010, they explain nearly half the rise in wealth concentration, with each of these components accounting for a similar share. Counterfactual simulations also show that higher wage dispersion due to skill biased technical change is the dominant factor, explaining 50-60% of the rise in wealth inequality.

Since the wealth distribution reacts more slowly to the economic environment than income, the full effect of the more recent changes in policy and wage dispersion has not yet fully materialized. Given today's wage structure and barring any further changes in tax and transfer policy, the model predicts two to three more decades of increasing wealth concentration, at which point the wealthiest 1% will eventually hold about half the wealth in the economy, roughly 10 percentage points more than their current share.

In contrast to their contribution to wealth inequality, top income tax cuts had no effect on the income distribution. The increase in income inequality is instead almost entirely attributable to the changes in the wage distribution. The difference comes from equilibrium adjustments in prices that work in opposing directions when income and wealth dispersions are concerned. Accumulation of additional wealth in response to tax cuts leads to a decline in the interest rate and an increase in the wage rate. The fall in the equilibrium interest rate discourages savings by lower wealth groups and exacerbates the direct effect of tax cuts on wealth inequality. As for income, the lower interest rate mitigates the rise in top incomes, while a higher wage rate benefits lower income groups as they live mainly off labor income. Therefore, changes in prices amplify the impact of tax cuts on wealth dispersion, while they mitigate their impact on income dispersion.

These results are in contrast to Atkinson, Piketty, and Saez (2011), who argue that top marginal income tax rates are a major factor in explaining income concentration across countries and over time in the US. This requires a large elasticity of top (pre-tax) income shares to the top marginal tax rate. The tax elasticity implied by the model here is instead much smaller once the changes in the wage dispersion are controlled for. The empirical literature has similarly found low elasticities (see Saez, Slemrod, and Giertz (2012) for a review), with the exception of Mertens (2013), who argues that changes in marginal income tax rates had substantial short-run effects on top income shares in the U.S.

Consumption inequality among working-age households increases roughly as much as the pre-tax income inequality, but less than the rise in disposable income inequality, consistent with the findings in the literature (Aguiar and Bils, 2011; Heathcote, Perri, and Violante, 2010). The model captures this with a combination of a decline in the savings rate for low and middle income groups and a slight increase in the savings rate for top income groups. The differences in the evolution of saving rates stem from incentives created for top income groups by lower taxes on corporate and estate income, and disincentives generated for others by a larger pension system and a lower equilibrium interest rate. The quantitative results are, therefore, compatible with Saez and Zucman (2014), who argue that falling savings rates for households outside the top income groups were a major contributor to the rise in wealth concentration in the US. The increase in consumption inequality is more limited in the general population, including retirees. Larger transfer payments in the form of better pension pay and medicare raise consumption expenditures by this typically low-consumption group, and attenuate the rise in consumption inequality driven by other factors.[2]

The model also provides a theory for recent trends in two key macroeconomic variables: the fall in the real interest rate and the rise in the wealth-to-income ratio (see Piketty and Zucman (2014) and Caballero, Farhi, and Gourinchas (2008) among others). We argue that these trends are a result of the savings incentives created by top income tax cuts, combined with the changes in the tax structure that shifted income to groups with higher savings rates. Both factors have led to an increase in the capital-to-income ratio, with a corresponding decline in the interest rate. The quantitative analysis indicates that both of these factors are economically significant, but have been partially offset by the reduction in savings generated by social security and medicare. As a result, the model explains half the decline in the real interest rate.

There is a substantial literature on tax reforms using macroeconomic models and quantitative methods. Castaneda, Diaz-Gimenez, and Rios-Rull (2003), Cagetti and De Nardi (2009) and De Nardi and Yang (forthcoming) all study the macroeconomic implications of hypothetical estate tax reforms. Domeij and Heathcote (2004) study the welfare implications of eliminating the capital income tax altogether. A few recent papers focus on the taxation of top income earners more specifically: Huggett and Badel (2014), Brüggemann and Yoo (2014), Guner, Lopez Daneri, and Ventura (2014) and Kindermann and Krueger (2014) all explore what the optimal marginal tax rate on income of the top 1% income earners should be. Similarly, Conesa and Krueger (2006), Heathcote, Storesletten, and Violante (2014) and Bakis, Kaymak, and Poschke (2015) study the optimal progressivity of income taxation in macroeconomic models with uninsurable, idiosyncratic productivity shocks. While the model in this paper and the economic mechanisms therein share some common elements with these studies, we differ from these papers by analyzing the historical changes in the actual tax and transfer system, combined with those in the wage distribution, and by focusing on their impact on top income and wealth shares.

The literature on increasing wage inequality is similarly large. Perhaps the closest study to ours is Heathcote, Storesletten, and Violante (2010), who analyze the effect of increasing wage inequality on trends in the distributions of hours worked, earnings, consumption, and welfare, but not of wealth.

The impact of social security provisions on aggregate savings behavior has been widely studied (see Feldstein and Liebman (2002) for a review), but little attention has been paid

[2]Gokhale, Kotlikoff, and Sabelhaus (1996) report that average consumption expenditures of seniors increased by 127% for females and 138% for males between 1960 and 1990, whereas they increased by about 60% among the general population.

to its impact on the cross-sectional wealth distribution. Papers on the distributional implications of social security have mostly focused on intergenerational allocations with the exception of Deaton, Gourinchas, and Paxson (2002), who argue that social security reduces wealth inequality by equating the rate of returns to savings among households in a model with heterogeneous returns to capital. We provide an argument to the contrary: due to partial coverage of earnings, the system has crowded out savings disproportionately for low and middle income groups, leading to larger wealth inequality. Huggett and Ventura (1999), Conesa and Krueger (1999), Fuster, Imrohoroglu, and Imrohoroglu (2003), Imrohoroglu and Imrohoroglu (1995) and Storesletten, Telmer, and Yaron (1999) have analyzed the implications of various social security configurations for consumption, labor supply, risk-sharing and welfare in macroeconomic models with idiosyncratic income risk. The current paper is similar to these studies in methodology, but differs in its focus on the tail of the wealth distribution.

In what follows, we first provide a brief discussion of the major changes in the US tax and transfer system in the post-WWI period. Section 3 presents the model and Sections 4 and 5 discuss the calibration of the model parameters. Section 6 presents the main findings from the transitional analysis of the evolution of the distributions of wealth and income. Section 7 provides a detailed analysis of long-run equilibria, and evalutes the relative roles of taxes, transfers and technology in the economy. Section 8 concludes.

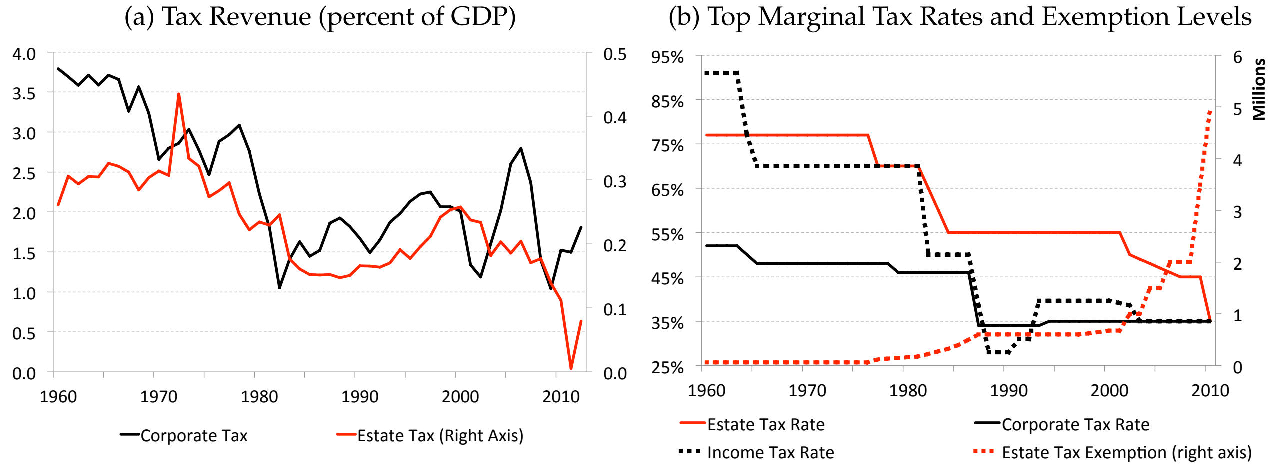
2 Changes in the US Tax and Transfer System: 1960 - 2010

This section provides a brief overview of the changes in the US tax and transfer policy since 1960, with a particular focus on the implications of these changes for top income groups relative to the overall population.

2.1 Tax Policies

The US tax system went through several reforms in the last 50 years that saw large drops in effective tax rates on top income groups. Two major components of this transformation were reductions in taxes imposed on corporations and on the transfer of large estates. Figure 1 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 effective marginal taxes on corporate income, which take into account tax exemptions and allowances and therefore are usually lower

Figure 1: Corporate and Estate Taxes: 1960 - 2010



Note.– Data for corporate tax revenues and GDP come from National Income and Product Accounts of the BEA. Data for estate tax revenues is taken from Joulfaian (2013). Data for statutory tax rates is taken from the IRS.

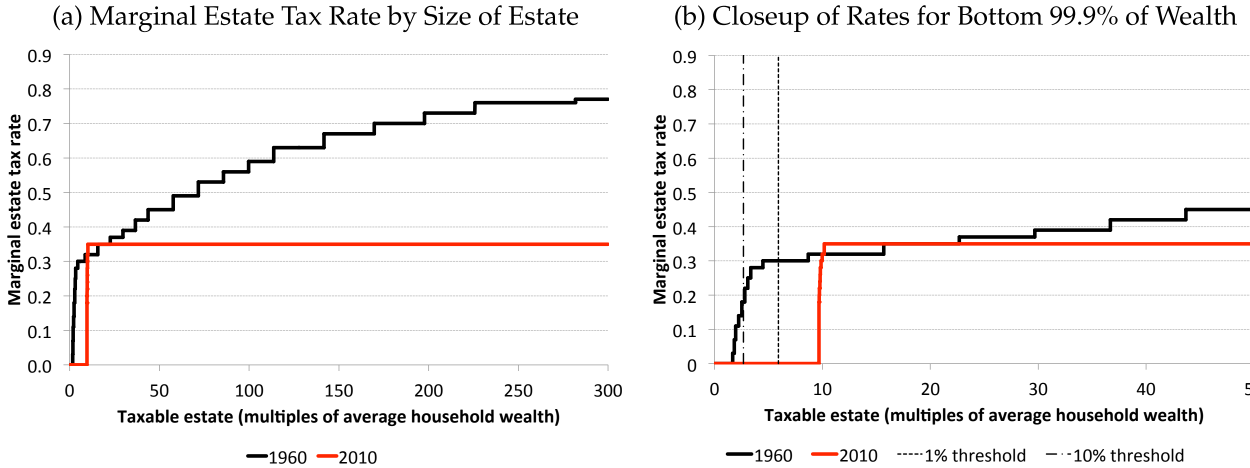
than the statutory rate. Gravelle (2004) and Gravelle (2014) report that a combination of tax exemptions, depreciation allowances and investment incentives reduced the average effective marginal tax rate on corporate profits from 42.0% in 1960 to 23.6% in 2010.

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 2, 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 2.

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 distributional effects of corporate and estate tax cuts across different income groups. Figure 3 shows the average effective tax rates by income for 1960 and 2004 from their study.[3] The average tax rate for all taxpayers was

[3] Note 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 2: The Estate Tax Schedule, 1960 and 2010



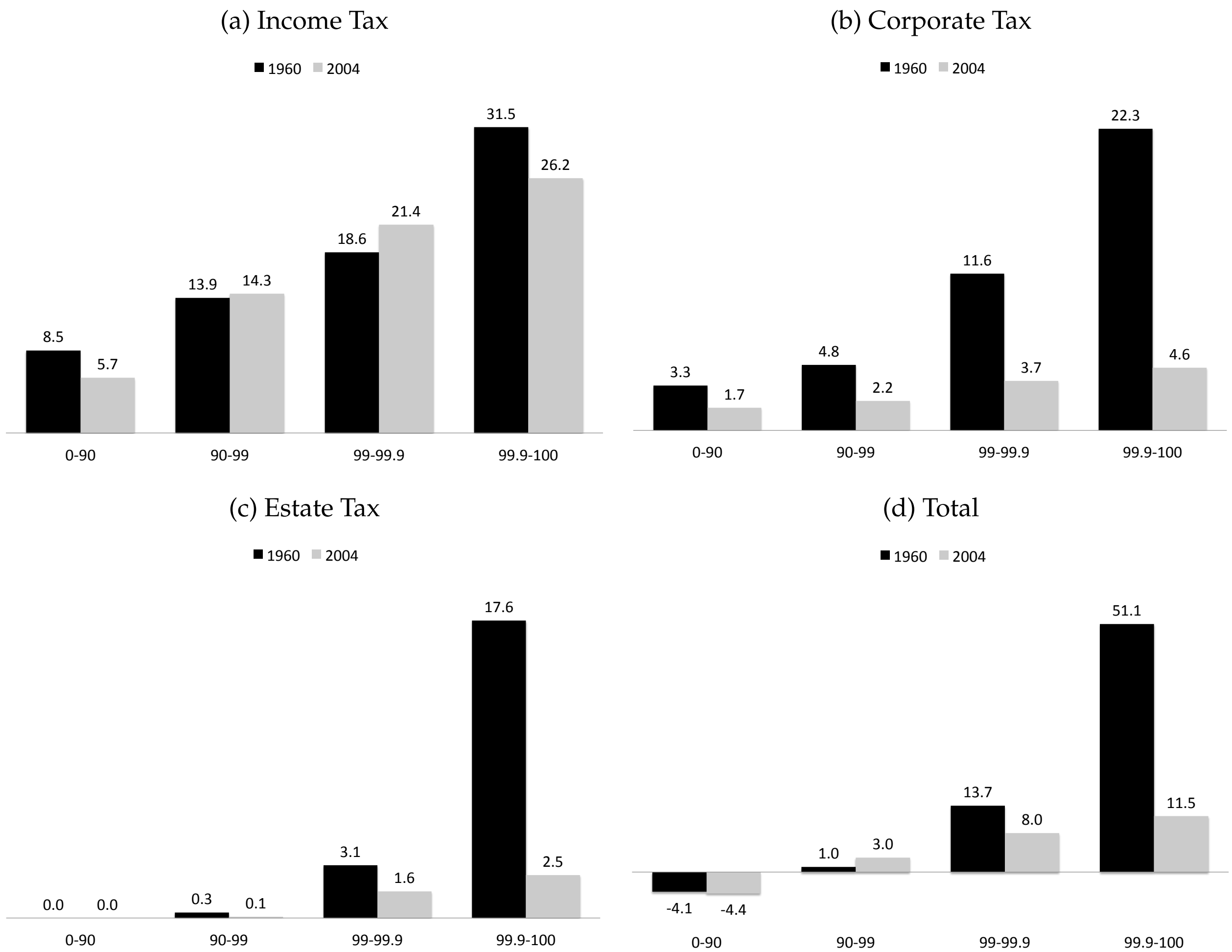
23.4% in 1970 and 23.3% in 2004. The average tax rate increased slightly for most in the bottom 99% of the income distribution, while it decreased substantially for all groups in the top 1% category. The magnitude of the drop in average tax rates varies between 4.8 percentage points for those between the 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 transfers 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. The federal income tax schedule also went through a dramatic change during this period, where the top marginal tax rate decreased from 91% to 35% (Figure 1). Despite this 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 91% top statutory marginal tax rate, applied only to a fraction of income for a handful of households. Panel (b) in Figure 3 shows that the decline in the federal income tax liabilities of top groups was relatively modest, and concerned only the top 0.5% of the income distribution.

2.2 Transfers to Seniors: Social Security and Medicare

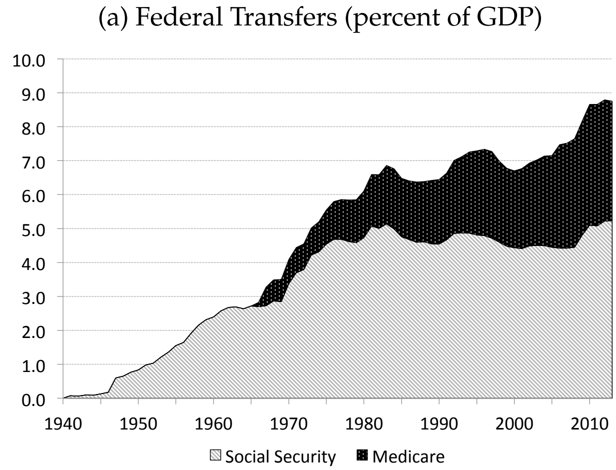
In addition to the declines in tax rates, there have been two major developments in transfer policies that are targeted at senior citizens: the expansion of the social security system,

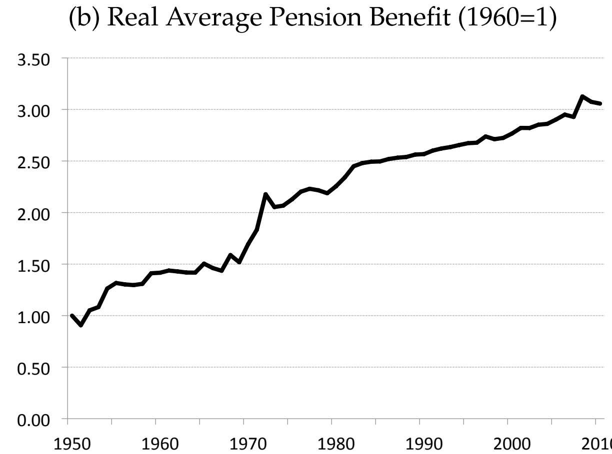
Figure 3: Average Federal Tax Rates by Income Groups



Note.– Figure shows the average tax rate by tax category for different percentiles of the income distribution. Panels (a)-(c) show average tax rates for each group in each year. Panel (d) shows the combined average tax rate (including payroll taxes) relative to the overall average tax rate in US. Data for tax rates come from Piketty and Saez (2007).

Figure 4: Transfers to Seniors: 1960 - 2010





Source: NIPA and SSA

and the introduction and expansion of Medicare. We argue that these programs have discouraged wealth accumulation by low and middle income groups, exacerbating the concentration of wealth. Figure 4 shows the share of each component relative to GDP since 1940. The foundations of the current social security system were legislated by 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 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.

The rise in social payouts is not explained by demographic changes although the share of seniors in the total population has been steadily rising. Figure 4b 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 larger benefits.

The impact of the expansion of the social security program has not been uniform across the income distribution. Due to caps on taxable income and associated limits on pension payouts, social security was a limited source of savings for high income groups. Furthermore, the formulas that link social insurance benefits to one's earnings history have traditionally been redistributive. Figure 5 shows the replacement rates as a function of a worker's average lifetime earnings relative to average earnings for 1960 and 2010.[4] The replacement rates decrease with earnings. In 1960, the lowest earnings groups received 40% of their average annual earnings in pension whereas those with 2.5 times the average, roughly the threshold for the top 5% of earnings, were entitled to less than 10% of their earnings in pension. At the time, maximum taxable earnings for social security was equal to average earnings. As a result, those above average earnings had only partial coverage. The expansion of the system during the 1970s and 80s raised the replacement rates from 16% to 44% for an average worker, but from 40% to 90% for the lowest earnings group. Those with higher than average earnings saw a more modest increase. Most of the gains in replacement rate for top income groups came from the increase in maximum taxable earnings from 1.03 to 2.5 times average earnings.

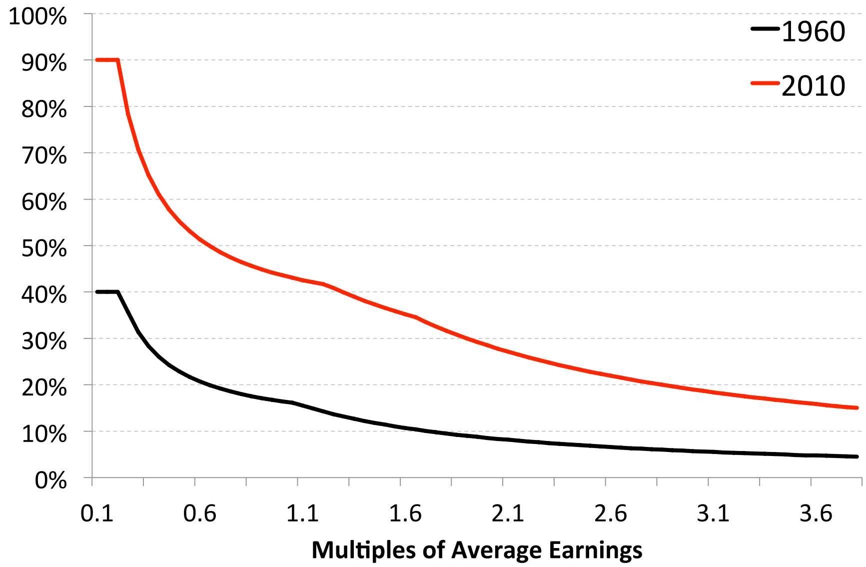
The second largest program that primarily targets senior citizens is Medicare, which is a national health insurance program.[5] It was started in 1966, and expanded greatly both in coverage and benefits since then. Currently, federal expenditures on Medicare stand at around 4.3% of GDP.

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 are likely to affect the saving incentives of workers with different levels of income and wealth differently.

[4]The replacement rates are calculated by applying the primary insurance formulas reported by the Social Security Administration 2013 Bulletin to multiples of average earnings in each year, also reported in the bulletin.

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

Figure 5: Social Security Replacement Rates by Earnings



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

We combine these elements of the tax and transfer system in US in a macroeconomic model of wealth distribution as described next.

3 Model

The effects of changes in taxes and the labor productivity distribution are analyzed using a modified version of the neoclassical dynamic stochastic general equilibrium model with uninsurable idiosyncratic income risk (Aiyagari, 1994; Bewley, 1986; Huggett, 1993). In particular, 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 a (discrete) 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 $\omega(\mathcal{R})$.

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 end-of-period capital holdings, before potentially paying estate taxes due on inheritance, and k the beginning of period 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 own welfare as much as 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

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

subject to

$$(1 + \tau_c)c + x = y^d(wzh, rk, \omega(\mathcal{R})) + k,$$
$$k' = x - E(x, \mathcal{R}, \mathcal{R}'),$$

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.

Given government expenditures G, a tax and transfer system characterized by $y^d(.)$ and $\omega(\mathcal{R})$, and a set of possible productivity levels $\{z_j\}$, a *stationary competitive equilibrium* of the model economy consists of a value function, $V(k, z, \mathcal{R})$, policy functions for factor supplies, $x(k, z, \mathcal{R})$ and $h(k, z, \mathcal{R})$, consumption $c(k, z, \mathcal{R})$, a wage rate, w, an interest rate, r, and an invariant probability measure Γ over the states $(k, z, \mathcal{R})$ such that:

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

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

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

3. Markets clear:

$$\begin{aligned} &K = (1 - M_1)\int x(k, z, 0)d\Gamma_0(k, z) + M_1\int [x(k, z, 1) - \mu_d E(x, 1, 0)]d\Gamma_1(k, z) \\ &N = \int zh(k, z, \mathcal{R})d\Gamma(k, z). \end{aligned}$$

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

5. The government budget is balanced:

$$\begin{aligned} G + M_1\int \omega(\mathcal{R})d\Gamma_1(k, z) = \quad & \tau_s \textstyle\int c(k, z)d\Gamma(k, z) + \int [y - y^d(y)]d\Gamma(k, z) \\ & + \mu_d M_1 \textstyle\int E(x, 1, 0)d\Gamma_1(x, z). \end{aligned}$$

In response to changes in government policies and technology, the economy switches from an initial stationary equilibrium to another one over time. Along the transition path, the economy is characterized by a cross-sectional probability measure Γ_t. Similarly, all value functions, policy functions, prices and equilibrium conditions are also indexed by a time indicator t. The market clearing condition for capital now reads:

$$K_{t+1} = (1 - M_1) \int x_t(k, z, 0) d\Gamma_{0t}(k, z) + M_1 \int [x_t(k, z, 1) - \mu_d E_t(x, 1, 0)] d\Gamma_{1t}(k, z)$$

and consistency requires Γ_{t+1} to be compatible with $F_0(z_{t+1}|z_t)$, $F_1(z_{t+1}|z_t)$, μ_r, μ_d and the savings policy $x_t(k, z, \mathcal{R})$. Note that, since the economy is initially at a stationary equilibrium, and since μ_d and μ_r are time-invariant, the share of retirees in the population remains constant. M_1 is thus not index by time.

4 Functional Forms and Calibration

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 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.

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.

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 the 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 $\{z_1, .., z_4\}$ are ordinary states and $\{z_5, z_6\}$ are extraordinary states reserved for exceptionally high earnings levels. 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 transitory 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 new 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 of having a low or high permanent component for a descendant of a household at the extraordinary state is the same as that of a household with a high permanent productivity component. The chances that the descendant of an extraordinarily productive household will also be as productive at birth is zero. Relaxing these restrictions leads to negligible improvements in the fit of the model.

Our working assumption is that the values for ordinary states and the transitions within are directly observed in the individual-level panel data, such as the PSID, whereas, due to topcoding, 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 PSID, the annual autocorrelation of 0.985, as estimated by Krueger and Ludwig (2013), the variance of log-earnings for working age households, which is reported as 0.504 by Heathcote, Perri, and Violante (2010) and the intergenerational elasticity of wages of 0.30 as reported by Solon (1999). Following Bakis, Kaymak, and Poschke (2015), the share of the permanent component in total wage variance is set to 62%, leaving 38% for life-cycle component. This leaves the transitional probabilities (λ_{in}, λ_{out}, λ_{ll}, λ_{lh}, λ_{hl}, λ_{hh}) and the extraordinary productivity levels z_5 and 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

[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.

of inequality for the distributions of income and wealth.[7]

4.3 Tax System

The tax system consists of personal income taxes levied on capital and labor earnings, corporate taxes, taxes on estate income and a sales tax. 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.[8] We set $\tau_c = 42\%$, which is the average effective 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.[9] 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.

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:

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

The first two terms above represent 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 (Bénabou, 2002), augmented by a flat rate for the top income tax bracket. y_b is the critical level of taxable income at which marginal tax rates are equal: $\lambda(1-\tau)y_b^{-\tau} = 1 - \tau_{max}$. The power parameter $0 \leq \tau \leq 1$ 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 sys-

[7] In addition to the 6 moments we target, there are two constraints on the row-sum of the probabilities in the transition matrix to equal unity.

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

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

tem is progressive.[10] See Guner, Kaygusuz, and Ventura (2014), Heathcote, Storesletten, and Violante (2014) and Bakis, Kaymak, and Poschke (2012) for evidence on the fit of this function. The top marginal tax rate in 1960 is set to 91%, as reported by the IRS. The progressivity of the general income tax system, τ is calibrated to match the average income tax rate for the top 1% of the income distribution as reported by Piketty and Saez (2007), which yields a value of 0.08. We obtained an alternative estimate of 0.05 using the average federal income tax rates by income deciles in 1960, as reported by Piketty and Saez (2007). Since estimates using federal income tax records exclude transfer income and state level taxes, this is likely a lower bound for the actual value of τ in 1960. Using the NBER tax simulator in combination with the household records in the PSID, we estimated τ to be 0.10 in 1978, the earliest year for which the state income taxes are included the simulator. Therefore, we find 0.08 to be a reasonable figure.

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 2. 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.[11] The sales tax rate is set to 2%.

The government uses the tax revenue to finance exogenous expenditures and transfers. Expenditures are set at 10.8% of GDP to yield a sum of expenditure and transfers 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 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_E and T_R accordingly, to match receipts per person. Finally, we choose λ in the personal income tax function to balance the government's budget.

4.4 Preferences

Preferences are described by a discount rate, β, the coefficient of relative risk aversion, 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

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

[11] The use of statutory rates would be a concern if actual rates were much lower due to , for instance, legal loopholes and tax avoidance. However, the discrepancy seems minor as we show below that the implied estate tax revenue from the model is in line with the data.

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 ($(r+\delta)K/Y$)	
δ	0.079	Capital-to-Income Ratio (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 Rate for Top 1%	0.24
τ_c	0.42	Marginal Corporate Tax Rate, Gravelle (2004)	
τ_e	Figure 2	Estate Tax Schedule, IRS.	
τ_s	0.02	Consumption Tax Rate	2%
γ	0.108	Government Expenditures/GDP	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	0.957	Interest Rate	0.041
θ	11.2	Average Hours Worked per Worker	0.35
ϵ	1.67	Frisch Elasticity	0.6
ψ^*	0.16	(Pension+Medicare)/GDP	2.5%
d_c/r	$0.45 \times K$	Corporate Tax Revenue/GDP	3.8%

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. We set $\sigma = 1.1$, which implies an elasticity of intertemporal substitution of 0.9.

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

5 Calibration Results for the 1960 economy

We begin by reporting and discussing parameters implied by the calibration, and then examine the fit of the model. The ordinary productivity levels and transition probabilities among them were already calibrated to match panel data on wages. Therefore we focus our discussion on the extraordinary states. At the stationary equilibrium, these states constitute 1.3% of the labor force, with the most productive state alone representing 0.08% of the workforce. Average productivity at these two states is 6 times as high as that of an average worker. The top state alone corresponds to 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. This helps generate a highly concentrated wealth distribution as observed in the data.

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%.[12] These figures imply a considerable degree of persistence in the high earner status. There is, unfortunately, little information on the transitions to, from and within extraordinary states in the data. Using micro-level data from the Social Security Administration (SSA), Kopczuk, Saez, and Song (2010) and Guvenen, Kaplan, and Song (2014) estimate the probability of staying in the top 1% of earners from one year to the next to be around 75%. The probability appears fairly stable over the years fluctuating between 70 to 80%. The corresponding probability implied by our calibration is 74%.

Guvenen et al. (2015) provide a detailed analysis of the distribution of earnings growth. They report a standard deviation of 1.1, a skewness of -1.26 and kurtosis of 18. The moments implied by our calibration are 0.76, -1.72 and 14. Considering that the model unit is a household whereas the reported data moments are for individual earnings, we think that the model provides a reasonable approximation of the earnings process in the data.

Top wealth status is slightly more persistent than the top earnings status in the model. The probability of staying in the top percentile of the wealth distribution from one year to the next is 85%. Data on wealth mobility is scarce since there is no consistent panel data on wealth in US. The only information we have comes from the 1983 and 1989 waves of the SCF, which include a panel on a subset of households (about 1500). Using these two waves, Kennickell and Starr-McClure (1997) estimate a persistence of 60% for the top percentile, which is well below the model persistence. While measurement error may explain some of the difference between the model and the data, more likely culprits are idiosyncratic fluctuations in wealth, e.g. due to medical expenses or stock market fluctuations, that are absent in the model.

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

[12]The full set of calibrated values for the transition matrices are reported in Table 11 in the appendix.

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**	**0.27**	0.46	0.63	0.79	0.92	0.99	**0.76**
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**	0.23	0.42	0.54	0.76	0.87	**0.33**
Earnings Share (Data)	0.05	0.07	0.20	0.33				0.34
Earnings Share (Model)	0.08	0.10	0.22	0.35	0.50	0.67	0.87	0.33

Note.– Calibration targets are in boldface. 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.

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 the 1962 Survey of the Financial Characteristics of Consumers (SFCC). The model closely approximates the distributions of income and wealth. The Gini coefficient of earnings in the model is very close to that reported by Heathcote, Perri, and Violante (2010), while top earnings shares are slightly higher in the model than in the data. The main reason for this discrepancy is that the data figures on top earnings shares 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 in the data.[13]

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

[13]Income from entrepreunurial 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	12.1	3.8	**3.8**	3.7	0.1	0.4	**24.1**	12.8	10.8

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). Calibration targets are in boldface.

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 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. At the same time, the model closely reflects the fact 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 closely replicates the data. 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.[14] 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

[14]Since 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 implies that their figures represent an upper bound for the estate tax paid by top income groups.

taxes, transfers and technology, which we turn to next.

6 The Evolution of the Income and Wealth Distributions since 1960

In this section, we present the evolution of the distributions of income and wealth over time implied by the model in response to changes in the distribution of labor productivity and tax and transfer policies. In particular, we solve for the transitional dynamics at an annual frequency from the 1960's steady state equilibrium to the one associated with the technology and policies in place in 2010. To do so, we change the tax and transfer policies and wage distribution in each year along the transition as observed in the data. The next subsection presents the details of how we implement these changes in the model. We then evaluate the model's performance in replicating the evolution of income and wealth distributions in the data, and discuss the relative contribution of each factor.

6.1 Taxes, Transfers and Wage Inequality since 1960

For the transition analysis, changes in the tax and transfer system and the wage distribution are introduced annually for the period 1960 to 2010. We assume that there are no further changes in the institutional environment or the technology of production after 2010. The full trajectory of changes in the environment is announced in 1960, and households are assumed to have perfect foresight over future changes from then on.[15]

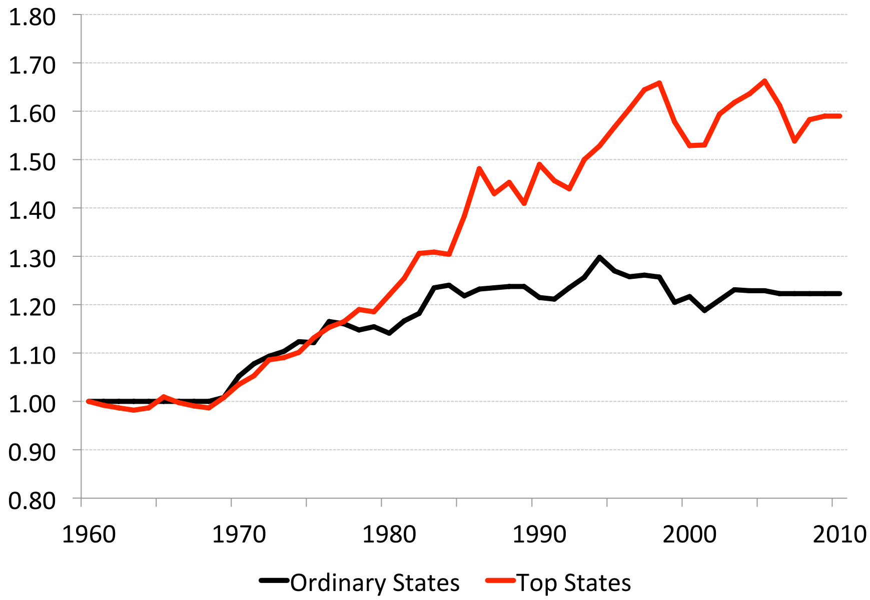
The changes in the wage distribution are modeled as an increase in the cross-sectional variance of labor productivity and calibrated based on survey data on households. Since our working assumption is that survey data excludes the extraordinarily high earnings levels, we calibrate these states separately based on the evolution of top wage income shares in tax records. This strategy is consistent with the observation that the earnings variance in the survey data remained fairly stable after the 1980s while the top 1% earnings concentration has continued to increase according to the IRS tax records. Our formulation can be summarized with the following equation:

$$\log z_{it} = \mu_t + \zeta_t \log z_{i \notin \{5,6\}} + \nu_t \log z_{i \in \{5,6\}},$$

Note that $i \in \{1, .., 6\}$ indexes labor productivity state, not households. Without loss of generality, we normalize ν_{1960} and ζ_{1960} to 1, and the (population) mean of $\log z_i$ to 0.

[15]These assumptions help us maintain computational tractability. While relaxing these assumptions could improve the model's short-run performance in the 1960s, we do not expect major changes to its predictions for longer horizons.

Figure 6: Technical Change and Wage Inequality



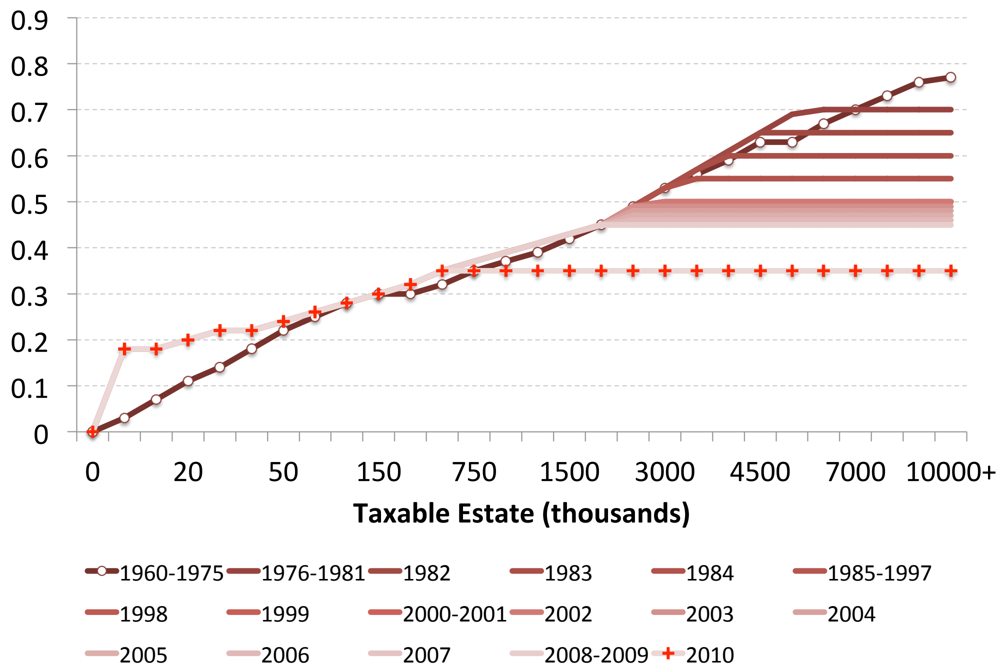
Note.– Figure shows the calibrated price of skill for ordinary and extraordinary productivity levels. The 1960 values are normalized to 1 in the figure.

With this normalization, ζ_t is the standard deviation of log-wages in year t relative to 1960 excluding the extraordinary states. We set ζ_t to match the growth in the variance of log-equivalized household earnings in the PSID as reported by Heathcote, Perri, and Violante (2010). [16] We then calibrate ν_t to the change in the top 1% wage income concentration as reported by Piketty and Saez (2011). Finally we adjust μ_t so that average labor productivity is constant throughout the analysis period. Figure 6 depicts the calibration results for ordinary and extraordinary states. The blue line depicts, ζ_t, the standard deviation of log-productivity outside the top states in each year relative to 1960. The red line reports the average level of log-productivity for the two extraordinary states relative to 1960.

Note that we keep the relative roles of transitory and permanent wage components fixed at all times. This implies that 62% of the rise in earnings dispersion is due to the permanent component, which is in line with the estimates based on survey data from

[16]Note that by calibrating ζ_t to the earnings variance, we implicitly ignore potential changes in the dispersion of hours worked across households, and assume that changes in the variance of earnings are due entirely to higher wage dispersion. However, we do not expect this to be a major limitation of the analysis: Heathcote, Perri, and Violante (2010) show that changes in household earnings inequality were dominated by changes in wage inequality. Relative hours of different wage groups changed little, with the exception of a decline in hours in the bottom 10% of the earnings distribution between 1967 and the early 1980s. For men, the variance of log annual hours was essentially constant from 1960 to 2005.

Figure 7: Statutory Estate Tax Rates: 1960-2010



the PSID (Heathcote, Storesletten, and Violante, 2010) and on tax records from the IRS (DeBecker et al., 2013).[17]

The changes in tax and transfer policies are incorporated in the model as follows. For the top marginal federal income tax rate, the series depicted in Figure 1b are used directly. The statutory top marginal income tax rate starts at 91%, drops gradually until it reaches 28% in the late 1980s, and is at 35% in 2010. For the taxation of corporate income, we rely on the average marginal corporate income tax rate estimated by Gravelle (2004) and Gravelle (2014). The series begin at 42% in 1960, and gradually declines to 23.6% in 2004. For estate taxes, we directly use the statutory rates in each year. The changes in the top marginal tax rate and the exemption level depicted in Figure 1b describe the evolution of the estate tax schedule well. Figure 7 shows the complete series of estate tax schedules between 1960 and 2010. We use these series directly in the transition analysis after normalizing the tax brackets as well as the exemption level by average wealth in the corresponding year.

The progressivity of the tax system τ_l is fixed at 0.08 in all years, and λ, which controls the average income tax rate, is set to adjust endogenously every period to ensure budget

[17] Heathcote, Storesletten, and Violante (2010) find a roughly even split between transitory and permanent components and DeBecker et al. (2013) report a 60-40 split in favor of the permanent component.

balance. Finally, we raise the transfers to retirees, $\omega_t(R)$, in proportion to the rise in the share of medicare and social security payments in GDP (see Figure 4).

6.2 Implications for Income and Wealth Concentration

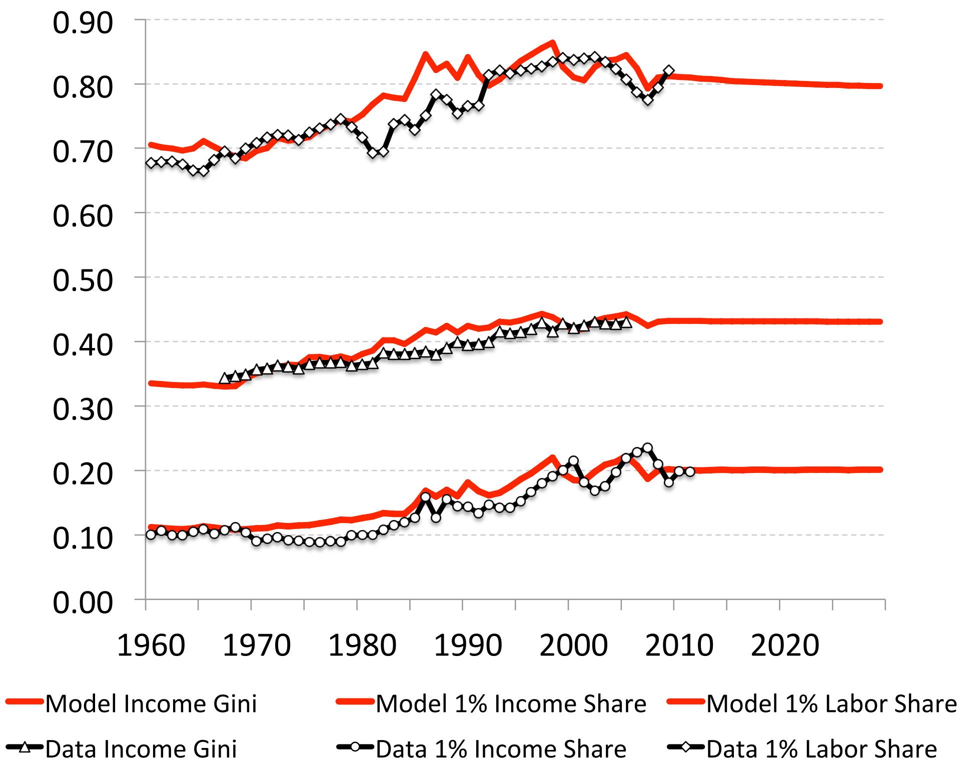
The model's predictions for the key moments of the income distribution are presented in Figure 8.[18] The lines with markers show the data values, and the solid gray lines depict the corresponding predictions of the model. The model closely tracks the observed changes in income inequality as measured by the Gini coefficient and the top 1% concentration ratio. An important feature of the rising income concentration in US is the role of earnings for top income groups. In the data, the share of income from labor for the highest 1% of incomes has increased from 68% to roughly 80% between 1960 and 2010. This is at odds with a story of rising income concentration that is based on tax cuts only, which have mainly targeted income from capital. The rising role of earnings indicate that the dominant factor in explaining the evolution of the income distribution has to originate from higher wage dispersion. That the model accurately captures the key aspects of the data on income inequality is reassuring for its implications for the wealth distribution, which we turn to next.

Figure 9 shows the main result of this section: the evolution of the top 1% wealth share in the model, compared to the data, for different model scenarios. The dark solid line indicates the benchmark model, with all the different factors in effect, and the line with triangles shows the corresponding data values. Apart from the decline in the 1% wealth share in the 1970s, which is associated with circumstances (rising oil prices, stock market crash) outside the current model, the evolution of the top 1% wealth share in the model parallels that in the data. In the period since 1980, the increase in the top 1% wealth share in the model matches that in the data almost exactly.

To highlight the relative contribution of different factors to changes in the wealth distribution, the two dashed lines in Figure 9 show the wealth concentration for counterfactual scenarios, where different factors are introduced sequentially in a cumulative manner. First, the changes in wage dispersion are introduced (dotted line), maintaining the 1960s tax and transfer policy. Then, tax cuts are introduced (asterisks). Raising the generosity of transfers in addition yields the solid benchmark line with all the factors. The graph reveals that a significant portion of the rise in wealth inequality can be explained by the changes in the wage distribution alone. Raising transfers to seniors has a smaller

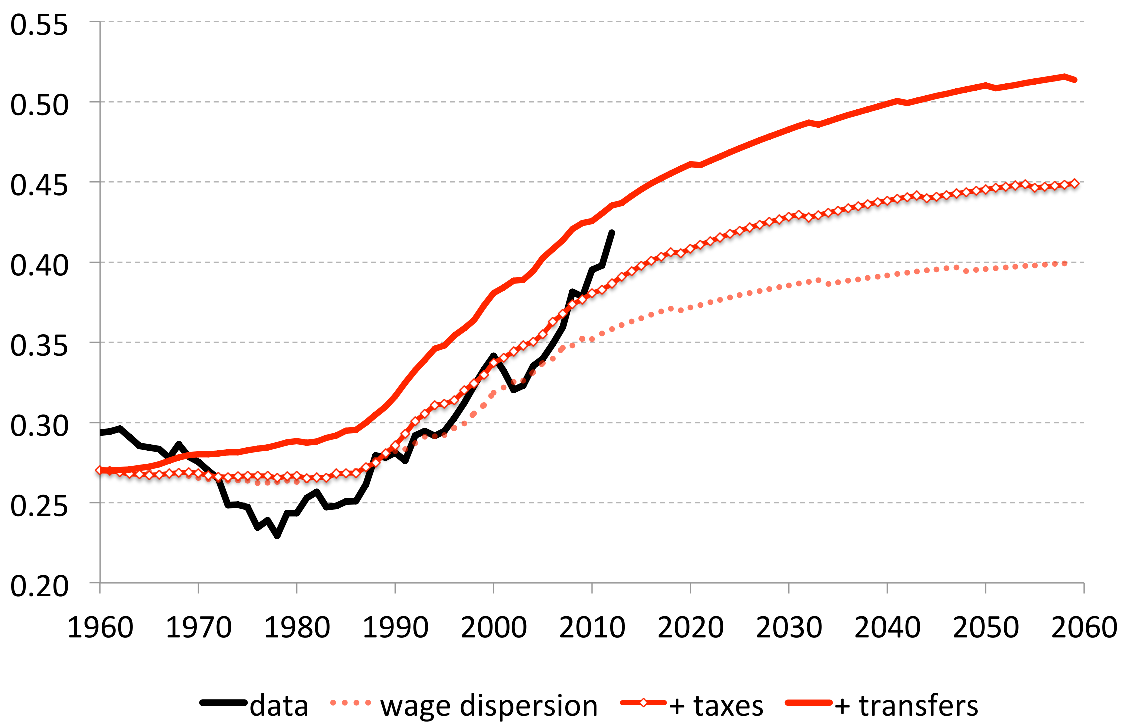
[18] In computing the transition dynamics, we allow the economy 150 years to converge. The figures in the paper often show shorter horizons as variables approach their long-run values sooner, and some sooner than others.

Figure 8: The Distribution and Composition of Income



Note.– Figure shows the evolution of the income distribution since 1960. Dark lines with markers show the data values and solid gray lines trace the corresponding predictions implied by the model. Data is taken from Piketty and Saez (2011). The share of income from labor includes salary income as well as 64% of entrepreneurial income.

Figure 9: The Top 1% Wealth Share since 1960: Model and Data



Note.– Figure shows the evolutin of the top 1% wealth concentration ratio in the model when higher wage dispersion, tax cuts and larger transfers are introduced sequentially. Thus the solid dark line (+transfers) shows the model's predictions when all factors are in place. Data values are taken from Saez and Zucman (2014).

but modest contribution, and tax cuts contribute the least, albeit still significantly.

A similar conclusion can be drawn from Table 4, which shows an alternative decomposition of the rise in wealth concentration by subperiod. The second column, shows the combined effect of all factors. Column 3 reports a counterfactual trajectory where only corporate and estate tax cuts are introduced. Column 4 decreases the top marginal tax rate on incomes in addition to the other tax cuts. Column 5 only raises the generosity of transfers to seniors, and the last column shows the trajectory of wealth concentration when only wage dispersion is increased.

Up until 1980, the model predicts a small increase in wealth concentration, driven mainly by larger pension payments and the introduction of medicare. There was a slight decline in top 1% earnings concentration during this period despite the rising variance of earnings overall. Therefore, the last column shows a small negative effect of introducing wage dispersion in isolation. Starting in 1980s, the rise in earnings dispersion picks up pace, and dominates the changes in wealth concentration. This factor alone explains more than half of the rise in wealth concentration after 1980.

Tax cuts generally have had a smaller contribution to changes in the top 1% wealth share, with most of their effect coming from lower federal income taxes. Nonetheless, the role of tax cuts is understated in the table for two reasons. First, tax cuts are more recent relative to the other factors, and it takes time for the wealth distribution to absorb their effects. This is evident in Figure 9, which shows that the effect of tax cuts appears in the 1990s and continues to grow well after 2010. Second, corporate and estate tax cuts have benefited those between 90th and 99th percentiles of the wealth distribution the most, a group that is absent in the table. A more detailed analysis on this aspect of tax cuts is provided in the next section. Finally note that the sum of changes in columns 3 through 6 does not equal the total change reported in the second column. This is due to interactions between different factors, when they are introduced together.

It is possible that a model generates realistic distributions of income and wealth without capturing the correlation between the two variables. However, the joint distribution of the variables is important for gauging the impact of policy changes, especially corporate and estate tax cuts, across the income distribution. Data for the joint distribution of wealth and income is not available for the entire period we analyze. Using data from the Survey of Consumer Finances, Kennickell (2009) reports an increase in the share of wealth held by top income groups between 1989 and 2007. Figure 10 compares the reported shares with the model's predictions along the transition during these years. The predictions for the top 1 and 5% of the income distribution is spot on. The model slightly undershoots the level of wealth held by those in the 90-95th percentile of the income dis-

Table 4: Changes in the top 1% wealth share, data and model

	data	model			
		all factors	only taxes	only wage dispersion	only transfers
Change by decade:					
1960s	-2.0	0.9	0.3	-0.2	1.1
1970s	-3.0	0.8	-0.1	-0.4	1.2
1980s	3.6	3.0	0.2	1.5	1.0
1990s	4.9	6.0	0.6	3.5	0.7
2000s	6.4	4.9	0.1	3.8	0.4
Total change:					
1960-2010	9.9	15.6	1.1	8.1	4.4
1980-2010	14.9	14.0	0.9	8.7	2.2
Contribution of each factor (% of total):					
1960-2010		1.0	0.07	0.52	0.28
1980-2010		1.0	0.07	0.62	0.15

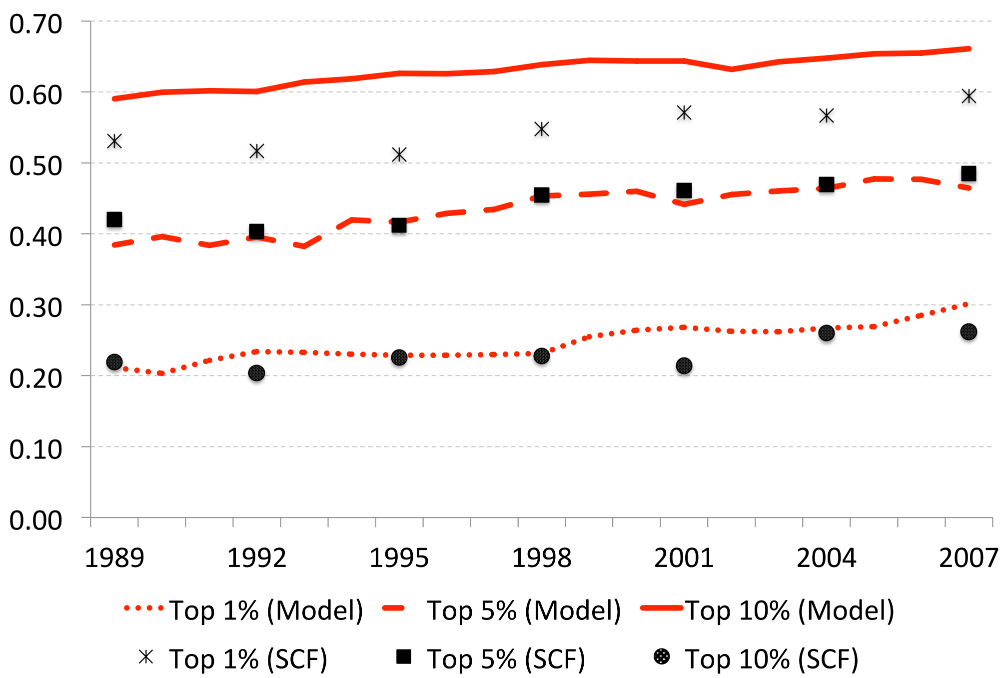
tribution, but captures changes over time for this group.

The speed with which wealth concentration responds to changes in the income distribution is remarkable.[19] Nonetheless, it takes the economy a long time to fully respond to the changes in the economic environment that have been going on since 1960. Figure 9 shows the model's prediction going into the future: wealth concentration will keep rising for several decades. Over time, wealth distribution converges to a long-run equilibrium where the wealthiest 1% holds about half the wealth in the economy. This, of course, assumes no further changes in fiscal policy and the production technology.

In the next section, we analyze the properties of the long-run, steady state equilibrium associated with the institutional and technological environment of 2010. Focusing on long-run equilibria bypasses complications related to the timing and anticipation of changes in taxes, transfers and technology, and makes it easier to describe the intuition behind their economic roles.

[19]This is in contrast to models that generate high levels of wealth concentration using random growth mechanisms, which have slow transitional dynamics, as pointed out by Moll et al. (2015). Note also that while our model shares some features with the extensions of the random growth model endorsed by these authors, the key mechanism generating top wealth concentration is different.

Figure 10: Share of Total Wealth held by Top Income Groups: 1989 - 2007



Note.– Figure compares the model's predictions for the share of total wealth held by top income groups with the values estimated by Kennickell (2009) from the Survey of Consumer Finances.

7 The New Steady-State: Where are we Headed?

In this section, we provide a detailed analysis of the long-run steady state equilibrium associated with the institutional and technological environment in 2010. To gauge the marginal contributions of taxes, transfers and technology separately, we simulate various hypothetical economies, where different factors are introduced in different combinations. The next subsection focuses on the key macroeconomic aggregates, followed by an analysis of income and wealth distributions, along with the model's implications for consumption inequality. Subsection 7.4 discusses the implications for the distribution of the tax burden.

7.1 Macroeconomic Aggregates

Table 5 shows the implications of the model for key macroeconomic variables in response to changes in taxes, transfers and technology. The benchmark values for the 1960 economy are reported in the first column. The second column shows the percentage changes in these variables at the steady state associated with the parameters of the 2010 economy. The remaining columns present the steady state equilibria for hypothetical economies, where each factor is introduced individually while others are kept at their 1960 values. The macroeconomic effects of tax cuts and technical change are qualitatively similar, but operate through different channels. The reduction in taxes raises the net marginal return to savings, encouraging wealth accumulation. Higher dispersion of wages represents a technical change in the production process that is biased towards the skilled labor force (Katz and Murphy, 1992). Since average labor productivity is maintained at its 1960 level, those below the average experience declines in productivity while the extraordinary states become much more productive. This considerably raises labor income risk in the model, encouraging higher precautionary savings in response. In addition, shifting disposable income to high-income and high-wealth agents, who have higher saving propensities, strongly promotes capital accumulation.

When all factors are combined, the capital stock increases by 20% in the long-run. The larger supply of capital creates a downward pressure on the interest rate and an upward pressure on the wage rate due to the complementarity of labor and capital in production. The pre-tax interest rate decreases by 1.3 percentage points and the wage per efficiency unit rises by 6.9%. Since average productivity is constant and labor supply elasticity is generally low, total hours worked do not change much (though dispersion in hours worked increases as discussed shortly). Consequently, output increases by 6.7%, which is entirely attributable to the higher capital stock. The implied capital-to-output ratio at the

Table 5: Tax Cuts and Macroeconomic Aggregates

Variable	1960 Benchmark	All Factors	Tax Cuts	Transfers	Higher Wage Dispersion
Capital	31.95	+20.0%	+13.1%	-12.4%	+16.6%
Labor	5.76	-0.2%	+0.3%	-0.4%	-0.9%
Output	10.68	+6.7%	+4.8%	-4.9%	+5.1%
Interest Rate (%)	4.1	2.8	3.2	5.2	2.9
Wage Rate	1.19	+6.9%	+4.4%	-5.5%	+6.0%
Consumption	7.00	+1.8%	+1.7%	-2.4%	+0.8%
Hours Worked	0.35	-0.5%	-0.0%	-0.5%	-0.1%
Tax Revenue/GDP (%)					
Income Taxes	11.3	19.8	13.4	17.5	11.8
Corporate Taxes	3.8	1.9	1.8	4.7	3.2
Estate Taxes	0.4	0.7	0.0	0.5	0.7

Note.– Table shows the model's predictions for key macroeconomic variables in response to changes in taxes, transfers and technology. The first column shows the 1960 benchmark values, and the other columns report percentage changes except for the interest rate and tax revenues. The second column shows the steady state values associated with the parameters of the 2010 economy. The remaining columns show hypethetical economies where each factor is introduced individually.

new steady state is 3.37, up from 3.0 in the benchmark economy in 1960.

These findings are consistent with studies that have documented an increase in the wealth-to-income ratio (Saez and Zucman, 2014) coupled with a secular decline in real interest rates in the US (see Caballero, Farhi, and Gourinchas (2008) among others). The rise in wage inequality as a theory of falling interest rates has been mentioned in the literature on secular stagnation (e.g. Eggertson and Mehrotra (2014)). As high income groups have a higher saving rate, the argument goes, redistribution of income towards these groups leads to an increase in the total capital stock relative to income. The last column in Table 5 implies that this explanation accounts for as much as a 1.2 percentage point drop in the interest rate. An alternative theory captured by the model emphasizes the corporate and estate tax cuts, which encouraged savings, especially by top income groups. The third column suggests that this is responsible for a 0.9 percentage point in the interest rate, almost as important as the wage inequality theory. Since transfers work in the opposite direction, the total change in the interest rate is 1.3 percentage point when all factors are considered. Caballero, Farhi, and Gourinchas (2008) report a 2.6 percentage point decline in the long-term real interest rate in US between 1990 and 2006, from roughly 4.5% to 1.9%. The corresponding decline during the transition in the model is 0.8 percentage points, nearly half the reported decline.

The last panel of Table 5 shows tax revenue as a share of GDP by source. In the absence of technological changes, lower estate and corporate taxes lead to a decline in tax revenue, which is compensated by a rise in taxes collected from personal income taxes due to the balanced budget requirement. The lower top marginal income tax rate also generates a revenue loss, but this is dwarfed by the increase in average tax rates. The overall tax burden is exacerbated by more generous transfers to seniors. However, this is mitigated by technological changes. Given the progressive nature of the overall tax system, rising top incomes help generate additional tax revenue. Since capital is more concentrated as a result of higher wage inequality, revenues from corporate and estate taxes increase as share of GDP, and ease up some of the pressure on personal income taxes brought about by cuts in tax rates. When interpreting the predictions regarding revenue-to-GDP ratios, the reader should keep in mind the contemporaneous balanced budget requirement imposed in the model. In reality, tax cuts or transfers can also be financed by government debt, which is not modeled here.

A more detailed analysis of the distribution of the tax burden is deferred to Section 7.4 below.

7.2 Distributions of Income and Wealth

Table 6 reports the model's prediction for the distributions of earnings, income and wealth associated with the steady-state of the new economy. The long-run distributions of income and earnings implied by the model closely replicate the observed values in 2010. This is not surprising since the impact of changes in tax system and technology on these variables is realized quickly, and we have assumed away any further changes after 2010. By contrast, the projected long-run distribution of wealth features much higher concentration ratios and a higher gini coefficient of inequality. This is partly because the wealth distribution is slow to respond to the economic environment and partly because some of the changes in the tax system, especially regarding estate taxes, are fairly recent. Given the current tax and transfer policy and barring any future changes in the wage distribution, the top 1% concentration ratio is projected to reach 52% and the Gini coefficient is to increase to 0.92 from its current value of 0.82.

Figure 11 shows the impact of different factors on the top 1% and 10% wealth and income shares. Beginning in the 1960 benchmark, each component is introduced sequentially, starting with higher wage dispersion, followed by corporate and estate tax cuts, top income tax cuts and finally larger transfers.

The largest changes in wealth concentration occur when higher wage dispersion is

Table 6: Income and Wealth Inequality in 2010

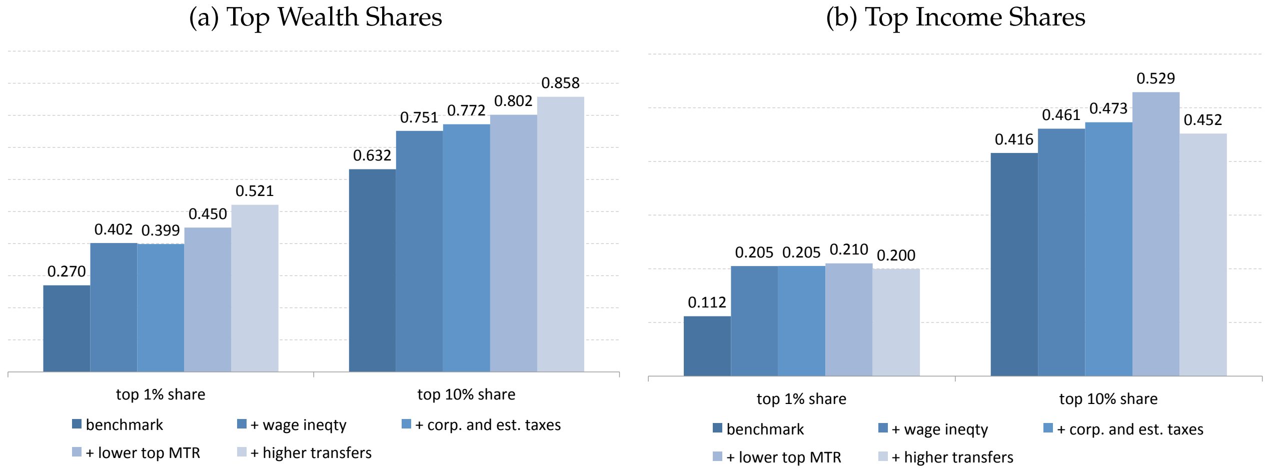
	Top Percentile							
	0.5%	1%	5%	10%	20%	40%	60%	Gini
Wealth Share (Data)	0.31	0.40	n/a	0.74	0.83	0.95	0.99	0.82
Wealth Share (Model)	0.43	0.52	0.74	0.86	0.98	1.0	1.0	0.92
Income Share (Data)	0.16	0.20	0.35	0.46	0.62	0.82	0.94	0.43
Income Share (Model)	0.16	0.20	0.34	0.45	0.53	0.75	0.88	0.43
Earnings 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

introduced. The top wealth share increases from 0.27 to 0.40 for the 1% and from 0.63 to 0.75 for the 10%. Given that these shares are 0.52 and 0.86 when all factors are considered, technology explains roughly half of the increase in wealth concentration in the model. The order in which different factors are introduced does not affect this conclusion by much. In all the combinations we computed, the marginal contribution of higher wage dispersion to top wealth shares varies between 50 and 60 percent of the total increase, with the largest impact occuring when they are introduced after the changes in tax or transfer policy. Hence, the change in wage inequality is the main driver of wealth concentration in US.

The share of the wealthiest 1% slightly declines in response to corporate and estate tax cuts, and rises in response to a lower top marginal income tax rate. However, the top 10% wealth share increases in response to both types of tax cuts. This is because concentration ratios depend not only on the wealth held by top groups, but also on wealth held by everyone else. Even though both top groups have higher wealth levels after the corporate and estate tax cuts, those in the 90-99% range accumulate disproportionately more wealth in response to estate tax cuts, driving up their share of aggregate wealth, and reducing that of the top 1%.

To better understand the impact of tax cuts on wealth inequality, consider Figure 12, which shows the change in saving propensities in response to tax cuts, where the saving propensity is defined as capital saved for tomorrow divided by disposable income plus wealth: $x'/(y^d + k)$. This is identical to $k'/(y^d + k)$ for households who survive into the next period. Panel (a) shows the saving reaction to estate tax cuts. The changes in the marginal estate tax rate by wealth group is shown with the dashed line. Recall from Figure 2 that the two main components of the estate tax reform were a much higher

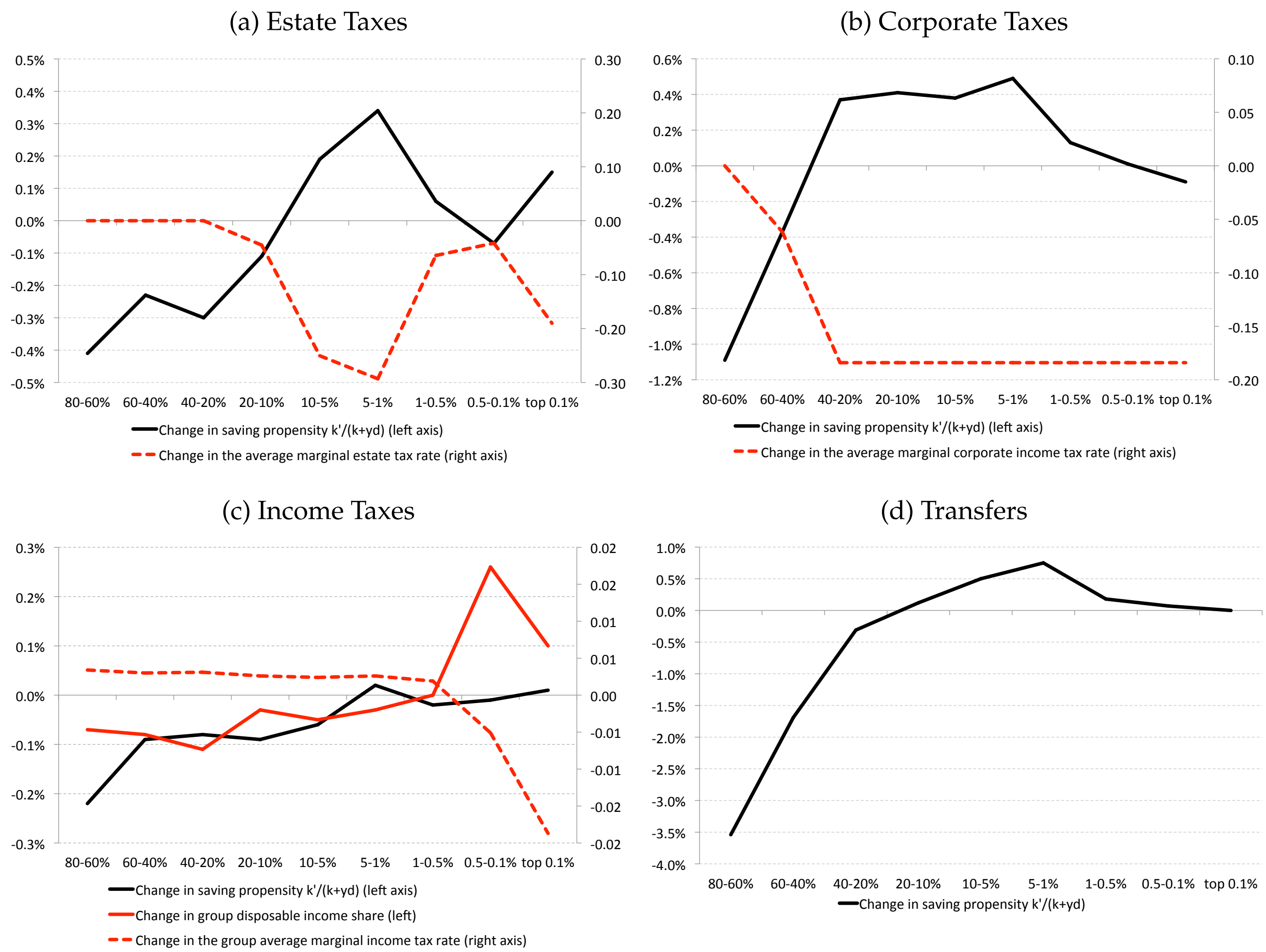
Figure 11: Decomposing the Rise in Inequality



exemption level and lower marginal rates at the top. This implies that the group experiencing the largest reduction in estate tax rates are high wealth groups just outside the top 1%. The wealthiest still pay estate taxes, albeit at lower rates than they did in 1960. In particular, since the top 77% tax rate in 1960 applied only at very high wealth levels, the reduction in the average marginal rate experienced by the top 0.1% group is modest. As a result, the strongest impact of the tax reform is on the behavior of the 90-99% group, which substantially increases its saving propensity, i.e., the substitution effect of a lower tax rate dominates the income effect. This behavioral change combined with the direct effect of lower taxes on estates implies that the wealth level of this group increases most. The wealth level of the top 1% group increases less, so that its share of total wealth declines. Those below the top 20% range are not directly affected by the estate tax cut, as their estates are always below the exemption level. Nevertheless, they react by saving less because the larger amount of wealth generated by the top groups decreases the equilibrium interest rate, reducing the return to saving.

A similar behavior is observed in Panel (b), which shows the savings reaction to the corporate tax cut. Since corporate assets are owned by the wealthy, only households in the top 40% range are directly affected (dashed line). Again, reactions can be interpreted in terms of substitution and income effects of the tax change, plus general equilibrium effects. Here, too, a stronger substitution effect leads to a higher propensity to save for households that benefit from the tax reduction. The response in the saving propensity declines with wealth due to a stronger income effect for top wealth groups. Those below the top 40% range reduce their saving rate in response to the lower equilibrium interest rate.

Figure 12: Saving Propensity and Marginal Tax Rates



Note.– The figure shows the saving reaction to changes in the tax system for different wealth groups (horizontal axis).

Panel (c) shows the effects of the lower top marginal income tax rate. The dashed line shows the ensuing change in each wealth group's average marginal income tax rate. Reducing the top rate from 91% to 35% results in a reduction in the average income tax rate for the wealthiest 0.1% of only 4 percentage points, since the top rate applies to only a small portion of their income. To balance the budget, taxes at lower income levels need to increase, raising the average marginal tax rate for all groups outside the top 0.5% of the wealth distribution by about half a percentage point. The top marginal tax rate cut can in principle affect the wealth distribution in two ways: directly, through its effect on the distribution of disposable income, and indirectly, via its effect on saving behavior. The dashed line shows the change in the share of disposable income of different wealth groups. This increases for the top 0.5% of the income distribution, and declines for all other groups due to the increase in the average tax rate. The savings response for top groups is small as the direct incentives due to tax cuts are offset by the decline in the equilibrium interest rate. Groups outside the top groups reduce their savings rates since they do not directly benefit from top income tax cuts. As a consequence, the share of wealth held by top 1% increases significantly. Their relatively high propensity to save implies that their share of wealth increases substantially more than their share of income. The effect of lower top taxes on wealth inequality thus is similar to that of higher wage dispersion in the sense that both work primarily via the distribution of disposable income. In contrast, the effect of corporate income and estate taxes, which hit capital, also goes through saving behavior.

Finally, panel (d) shows the effects of larger transfers on saving behavior. The direct effect of larger transfers for seniors is to substitute away from saving for retirement. This effect is the largest for lower wealth groups as for them, the transfers are largest relative to benchmark retirement savings. Had the interest rate been constant, the savings rates would have decreased for all. However, the larger interest rate resulting from lower overall wealth, generates a substitution effect that encourages savings. This effect is is stronger for the higher wealth groups than the direct savings replacement effect. As a result, the saving propensities of those in the top 20% of the distribution increases overall.

Combined, the changes in tax and transfer policies explains nearly half the change in wealth concentration. The numbers in Figure 11a suggest that tax cuts alone explain roughly 20% of the change in wealth concentration, suggesting a larger role for transfer policy compared to tax cuts. This, however, is not robust to the order in which the two factors are introduced. When tax cuts are introduced after more generous transfers are already in place, the marginal contributions are flipped with tax cuts accounting for 30% of the total change and transfers for 20%. This is because larger transfers reduce total

Table 7: Tax Cuts and Economic Inequality:

Variable	1960 Benchmark	All Factors	Tax Cuts	Transfers	Higher Wage Dispersion
Wealth	0.76	0.92	0.80	0.81	0.85
Income (all)	0.50	0.53	0.50	0.44	0.59
Income (working age)	0.33	0.43	0.33	0.34	0.42

Note.– Table reports the Gini coefficients of inequality for the entire population obtained by model simulations.

wealth in the economy and raise the concentration of wealth at the same time. When top income tax cuts are introduced in such an environment, the change in the top wealth share is bigger relative to total wealth. It would be fair to say that taxes and transfers are similarly important for explaining the top wealth shares.

In contrast to the wealth distribution, top 1% *pre-tax* income shares in Figure 11b are hardly affected by tax and transfer policy. This is explained entirely by higher wage concentration in the data. A similar conclusion could be drawn for the top 10% share, where higher wage dispersion raises the concentration ratio from 0.42 to 0.46, whereas changes in policy reduces it back to 0.45. This is robust to the ordering of counterfactual scenarios. Nonetheless, there is an evident tension between top income tax cuts and transfer payments that work in opposite directions. While tax cuts raise the share of income held by those in the 90-99 percentile range, larger transfers to retirees reduce it. That the transfers reduce income inequality is partly an accounting artifact. Since pensions are taxable, they are included in the total pre-tax income. However, in a pay-as-you-go system, pension payments are financed out of taxes, which are not subtracted from pre-tax income. Therefore, larger transfers seemingly raise total income, lowering the income share of non-retirees. Otherwise, transfers have no affect on the pre-tax income distribution among workers. It should also be noted that the marginal contribution of top income tax cuts, evidently sizable in Figure 11b, is specific to the order in which policies are introduced. In all other configurations, top income tax cuts raise the top 10% income share by less than 2 percentage points. Similarly, the marginal impact of transfers are less than 3 percentage points.

Next, we revert our attention from top income and wealth shares to overall inequality. Table 7 shows the Gini coefficients of inequality for wealth and income. When all factors are considered, the Gini for wealth increases from 0.76 to 0.92. Comparing the counterfactual equilibria reported in columns 3 through 5, where each factor is introduced separately, all factors contribute significantly to the wealth Gini with higher wage dispersion having the largest impact. Interactions between different factors make it difficult to measure the marginal contribution of each on wealth inequality. For instance, tax cuts may matter more if the income concentration is already high when they are introduced. We find that the marginal impact on the wealth Gini varies between 4 and 9 points for higher wage dispersion and transfers, and between 4 and 7 points for tax cuts in all configurations.[20] While it would not be entirely accurate to apportion the total change in this way as the Gini coefficient itself is not additive, the results broadly suggest that higher wage dispersion contributed to wealth inequality the most, followed by transfers, and then taxes.

A second result that emerges from Table 7 is that tax cuts have had little effect on overall income inequality. For the working age population, the rise in the Gini coefficient is driven almost entirely by higher wage dispersion. When seniors are included in the sample, the rise in income inequality is lessened by larger transfers. As a result, whereas the Gini coefficient for income increases by 10 points from 0.33 to 0.43 among workers, it increases by 3 points from 0.50 to 0.53 for the overall population.

That tax cuts have a significant effect on wealth inequality, but not on income inequality can be attributed for the most part to general equilibrium effects in factor prices. The lower interest rate brought about by the higher capital stock, combined with a higher wage rate shifts some of the gains experienced by the wealthy over to lower income groups who rely more heavily on labor income. This mitigates the effect of top icnome tax cuts on income inequality. However, the lower interest rate also discourages savings by lower income groups who don't directly benefit from these tax cuts, and amplifies the effect of top income tax cuts on wealth inequality.

There is extensive work on the elasticity of top income shares to *net-of-tax* rates in the empirical literature. Piketty, Saez, and Stantcheva (2014) relate the changes in the top 1% income share with the changes in the top marginal income tax rate across countries between 1960 and 2009, and report an elasticity of 0.25 to 0.30 for US, and 0.31 to 0.37 range across countries, depending on the control variables. Comparing long-run equilibria associated with 1960 and 2010 environment results in an estimate of 0.30.[21] This is not surprising since we take the top marginal tax rate from the data and the model

[20]The marginal impact of wage dispersion is 9 points when introduced alone, 9 points if introduced after tax cuts, but before transfers, and 4 points if introduced last. The marginal effect of transfers is 5 points when introduced alone, 9 points when introduced after taxes, but before wage dispersion and 4 points when introduced last. The marginal effect of tax cuts is 4 points when introduced alone, 7 points if introduced after transfers, but before wage dispersion and 3 points if introduced last.

[21]Given our results, the formula is $0.30 = (\ln(0.20) - \ln(0.11))/(\ln(1-0.35) - \ln(1-0.91))$.

matches the trends in the top 1% income share. Of course, this is more of a correlation than a causal elasticity since it combines the effect of all factors, not just the top marginal tax rate. Based on counterfactual experiments, where only the top marginal income tax rate changes, the long-run elasticity is less than 0.15! This is essentially because the 91% top marginal tax rate concerns a handful of people, and slightly reducing it leaves most households in the 1% category with the same marginal taxes. For instance, if we compare fictitious 1960 economies where the top marginal tax rates were changed instead from 0.36 to 0.40, then the elasticity estimate is 0.25, more in line with the estimates in Piketty, Saez, and Stantcheva (2014) controlling for time trends or country fixed effects. An even better estimate would be based on the change in the average marginal tax rate for the top 1% income group instead of the top marginal tax rate (Saez, Slemrod, and Giertz, 2012). This modification leads to an elasticity of 0.45 in 1960, when the top marginal tax rate is decreased to 0.35 leaving other factors constant. Various alternatives, where tax cuts are introduced before or after transfers and/or technical change give a range of estimates between 0.15 and 0.45. Saez, Slemrod, and Giertz (2012) report the range of "most reliable long-run estimates" to be 0.12 to 0.40.

7.3 Distributions of Disposable Income, Consumption and Hours

Perhaps the most striking difference between tax cuts and transfers is their impact on consumption inequality. Although both factors are significant drivers of wealth inequality, transfers significantly reduce consumption inequality. Table 8 shows measures of dispersion for disposable income and consumption. Disposable income is generally less dispersed than pretax income due to the progressivity of the tax system. In the 1960 benchmark, the Gini coefficient for disposable income is 0.45 whereas for pretax income, it is 0.50. The Gini for consumption is even lower at 0.41 as households can insure themselves against fluctuations in their income by accumulating wealth. A similar pattern can be observed in share of total consumption enjoyed by top (pre-tax) income groups.

The intermediate lines in Table 8 show the changes to the benchmark distributions when taxes, transfers and higher wage dispersion are introduced individually. Tax cuts alone slightly raise the inequality in disposable income as observed in the Gini as well the concentration ratios. Consequently, overall consumption inequality increases. The corporate and estate tax cuts operate in a different way than the reduction in the top income tax rate for consumption shares. By raising the effective return on savings, they encourage top income groups to substitute away from consumption towards wealth accumulation. This can be seen in the consumption shares of top (pretax) income groups, which increase less than their disposable income share. This is also why the concentration of consump-

Table 8: Distributions of Consumption and Disposable Income

Consumption	log-var.	Gini	*by consumption* top 1%	*by consumption* top 10%	*by pre-tax income* top 1%	*by pre-tax income* top 10%
Benchmark	0.510	0.406	0.128	0.322	0.061	0.319
- Tax Cuts	0.528	0.415	0.124	0.329	0.068	0.318
- Transfers	0.357	0.358	0.073	0.304	0.066	0.298
- Wage Dispersion	0.645	0.477	0.114	0.391	0.090	0.382
All Factors	0.542	0.452	0.141	0.387	0.109	0.379
			by disp. income		*by pre-tax income*	
Disposable Income	log-var.	Gini	top 1%	top 10%	top 1%	top 10%
Benchmark	0.596	0.446	0.086	0.376	0.086	0.374
- Tax Cuts	0.624	0.458	0.096	0.386	0.096	0.382
- Transfers	0.389	0.382	0.085	0.344	0.085	0.345
- Wage Dispersion	0.710	0.523	0.158	0.461	0.158	0.463
All Factors	0.559	0.490	0.180	0.465	0.180	0.459

Note.– Table shows measures of inequality for consumption and disposable income from the model. Columns 3 and 4 order households by consumption or disposable income to compute concentration ratios. Columns 5 and 6 order them by pretax income.

tion does not increase as much as the concentration of disposable income in response to tax cuts.

An increase in transfers works in the opposite direction, reducing inequality in both disposable income and consumption. This is essentially due to the redistributive nature of the transfer system. Even though, transfers and tax cuts have a more or less comparable impact on wealth inequality, the implications for consumption inequality are quite different not only in direction, but also in size. While tax cuts raise the consumption Gini by 0.9 points, transfers reduce it by 4.8 points.

Finally, a higher wage dispersion significantly raises consumption inequality. Alone, they raise the consumption Gini by 7.1 points and the variance of log-consumption by 0.14, or 26%. Since the productivity distribution is mean preserving, the rise in inequality is driven by increased consumption by top income groups (Columns 5 and 6) as well as reduced consumption for low income groups. The impact of wage dispersion on the top consumption shares is less clear as it depends on whether those consuming the most rely more on earnings or capital income. In the model, the top 1% consumers are more reliant on capital income than earnings, whereas those in the 1-10% range are high earners. As a result, the share of top 1% consumers declines as their capital income declines along with the equilibrium interest rate while the top 10% share increases.

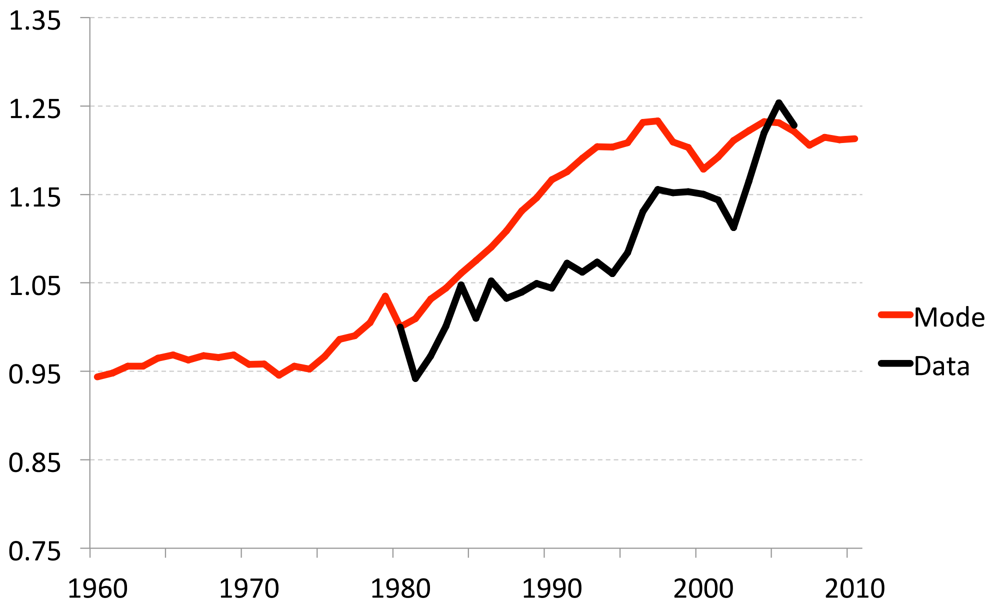
All factors combined, consumption inequality increases significantly, though not as much as it would have in the absence of the changes in transfer policy. The Gini coefficient increases from 0.41 to 0.45.

That consumption inequality has been increasing is consistent with the findings in Aguiar and Bils (2011) and Heathcote, Perri, and Violante (2010). The latter authors report that the log-consumption variance increased by 23% between 1980 and 2006 for working age households in the Consumption Expenditure Survey. To compare the model's prediction with their results, we computed the variance of log-consumption for non-retirees, excluding the top 1% of the distribution. Figure 13 compares the results with the values reported in Heathcote, Perri, and Violante (2010). The values in 1980 are normalized to 1 in both series.[22] The model closely matches the rise in consumption dispersion reported by Heathcote, Perri, and Violante (2010).

The distribution of hours worked is summarized in Table 9. Average hours worked is calibrated to 0.35 and the cross-sectional variation across households is generally small due to low elasticity of labor supply. Nevertheless, households work considerably more

[22]The model generally predicts a larger consumption variance than in the CEX. For instance, the model predicts a log-variance of 0.49, whereas the data value is 0.27. Possible reasons include measurement error, reportedly an important problem for CEX (Aguiar and Bils, 2011), a higher dispersion in durable goods consumption or model misspecification.

Figure 13: Consumption Inequality: 1960-2010



Note.– Figure shows the variance of log-consumption for working population (1980=1). Data values are based on the CEX, and are taken from Heathcote, Perri, and Violante (2010). For comparability, model statistic excludes 1% of households with highest incomes.

Table 9: Distribution of Hours Worked

		productivity		income	
	average	z_5	z_6	top 1%	99%
Benchmark	0.351	1.17	1.59	0.353	0.351
- Tax Cuts	0.351	1.18	1.64	0.358	0.351
- Transfers	0.349	1.18	1.60	0.309	0.350
- Wage Dispersion	0.350	1.29	1.57	0.429	0.349
All Factors	0.349	1.33	1.64	0.425	0.348

Note.– Table reports hours worked for different income and wage groups. Total hours available is normalized to 1. Columns 2 and 3 report hours worked for high wage workers in the model relative to average in column 1.

when they are productive. Despite the persistence of these states implied by the transition probabilities, they are still transitory. Consequently, households take advantage of their current productivity by working harder and accumulating savings for retirement and against the risk of losing their productive status. On average, households in these states work 20% longer hours than an average household, 59% if they are in the most productive state. Considering that weekly average hours worked in the US is roughly 35 hours, the highly productive household in top states work 42-hour weeks, or 56-hour weeks if they are in the top state. With the introduction of lower tax rates combined with higher wages, these households work 35% more on average, or 47 weekly hours, and 64% if they are in the top state, or 57 hours a week.

Comparisons across income groups are less straightforward since top income groups may contain not only high earner households, but also the wealthy ones, who enjoy more leisure due to income effects. In fact, the 1960 benchmark features fairly similar hours worked for top income groups. However, when wage inequality is higher, top income groups contain more top earners (recall that the share of labor income for that category increases over time in Figure 8). As a result, average hours worked among top 1% of income earners increases. The model predicts that this category works 21% longer hours, or 42 hours a week.

7.4 Distribution of the Tax Burden

The reduction in taxes paid by top income groups, ceteris paribus, shifts the tax burden onto lower income groups. This is counteracted by the expansion of the tax base due to two reasons: first, the increase in savings and labor supply in response to tax cuts generates additional income, which generates tax revenue; second, the rise in wage dispersion raises earnings for top income groups and lowers it for lower income groups. Since the tax system is generally progressive, the additional tax revenue collected from high income earners more than compensates for lost revenue at the bottom of the income distribution. Table 10 shows the share of taxes paid by various wealth and income groups for each tax category. The first panel shows the distribution of the estate taxes for different wealth groups. The direct of effect of higher exemption levels is an obvious increase in the share of taxes paid by the very wealthy. This is despite the additional wealth generated by the tax cut. Introducing other factors in addition to the tax cuts raises the capital stock further, pushing some of the households above the exemption level. All factors combined, the wealthy pay a larger share of the estate taxes, but total revenues fall.

A similar pattern is observed in corporate income taxes. Here, the direct effect of the tax cuts appears more limited because the households are ordered by income instead

Table 10: Distribution of the Tax Burden

	Top Shares					
	0.5%	1%	5%	10%	20%	40%
Estate taxes, ordered by wealth (retirees only):						
Benchmark	73.0	82.8	97.8	100.0	100.0	100.0
+ Tax Cuts Only	94.2	100.0	100.0	100.0	100.0	100.0
All Factors	89.2	99.8	100.0	100.0	100.0	100.0
Corporate income taxes, ordered by pre-tax income:						
Benchmark	26.8	28.6	52.6	67.5	82.5	85.2
+ Tax Cuts Only	26.9	29.2	42.7	67.1	83.4	85.6
All Factors	34.4	40.4	60.0	74.5	91.2	94.4
Income taxes, ordered by pre-tax income:						
Benchmark	16.2	19.0	41.6	57.4	67.3	87.9
+ Tax Cuts Only	12.8	15.4	33.2	52.8	63.6	85.3
All Factors	18.7	23.6	39.4	57.9	76.8	80.6
Data (2010)	–	24.2	41.4	53.3	68.6	86.4

Note.– Table shows the percent share of taxes paid by various wealth and income groups for each tax category. The lines labelled "-Tax Cuts" show the results from the steady-state equilibria where only the mentioned factor is introduced to the 1960 benchmark economy. Data values for income tax distribution is taken from the Congressional Budget Office (CBO, 2011).

of wealth. In such a case, the direct effect of tax cuts on capital are diluted as all top income groups contain some households with low wealth, and, thus, do not benefit from the tax cuts. By contrast, the effects of wage dispersion is more apparent as it correlated highly with total income. The top 1% of the wage distribution, for instance, pays 40% of corporate income taxes, up from 28.6% in 1960, despite the large declines in the marginal corporate tax rate.

The last panel shows the distribution of income tax payments by income. Here, the lower top marginal tax rate reduces the share of taxes paid by top income groups. This, however, is undone by the expansion of top incomes, and the top groups pay, as a result, a larger share of income taxes. The last line in this panel compares the results with the share of taxes paid in the data, reported by the Congressional Budget Office (CBO, 2011). The model captures the changes in the data for top income groups fairly well, though the households in the second quintile contribute slightly more in the model, and those in the third quintile almost equally less.

8 Conclusion

The findings emphasize the role of increasing wage dispersion, often attributed to skill biased technical change, as the main culprit of higher income and wealth inequality in the US. Changes in tax and transfer policies over the second half of the 20th century have played a key role, accounting for nearly half of the rise in wealth concentration. Nevertheless, their combined effect on the distribution of income and consumption were limited. The results indicate the equilibrium adjustment in prices, the redistributive nature of transfers and the offsetting effects of taxes and transfers on consumption as main reasons for this limited role. As such, the results call for caution when drawing conclusions regarding welfare, based on income and wealth distributions.

An interpretation of our findings is that changes in the transfer policies have been as influential as the changes in tax policies. Yet, unlike the wide coverage of falling top income tax rates, changes in the transfer system has received little attention of late. Our focus has been on two major federal programs: the social security and medicare. Several other programs were introduced during this period, both at the federal and the state level, that could potentially have similar effects on the economy, such as the Earned Income Tax Credit program or the Welfare-to-Work programs. Given the redistributive nature of transfers in US, our findings highlight the need for empirical measures of wealth dispersion including claims on the public sector. The findings here suggest that such a measure would generally display a lower concentration of wealth, and a smaller increase over time.

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9 Appendix: Additional Tables and Figures

Table 11: The Transition Matrices for The Productivity Process

Π_{WW} (surviving workers):

$z_W \backslash z_W$	**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

Π_{RW} (retiree to new worker):

$z_W \backslash z_W$	**6.7**	**19.2**	**20.5**	**58.4**	**61.4**	**1222**
6.7	0.043	0	0.023	0	0	0
19.2	0.043	0	0.023	0	0	0
20.5	0.023	0	0.043	0	0	0
58.4	0.023	0	0.043	0	0	0
61.4	0.023	0	0.043	0	0	0
1222	0.023	0	0.043	0	0	0

Note.– Table shows the calibrated transition probabilities for workers over the life-cycle, Π_{WW}, and for retiree to new worker transitions (at death), Π_{RW}.