Politico Economic Consequences 
of Rising Wage Inequality 
(Preliminary and Incomplete)

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Abstract

This paper uses a dynamic political economy model to evaluate whether the observed rise in wage inequality and decrease in median to mean wages can explain some portion of the increase in transfers to low earnings quintiles and increase in effective tax rates for high earnings quintiles in the U.S. over the past two decades. Specifically, we assume that households have uninsurable idiosyncratic labor efficiency shocks and consider policy choices by a median voter which are required to be consistent with a sequential equilibrium. We deal with the problem that policy outcomes affect the evolution of the wealth distribution by approximating the distribution by a small set of moments. We calibrate the model to match properties of the U.S. earnings distribution and effective tax rates in 1983 and then evaluate the response of the social insurance policies to the observed rise in wage inequality over the next decade and a half. We contrast these numbers with those from a sequential utilitarian mechanism, as well as mechanisms with commitment.

1 Introduction

In this paper we ask whether the observed increase in wage inequality and the decrease in median to mean wages can explain some part of the increase in transfers to low earnings quintiles and increase in effective tax rates for high earnings quintiles in the U.S. over the past two decades. To answer this question we use a model with uninsurable, idiosyncratic shocks to labor efficiency similar to Aiyagari [1]. With incomplete markets, the rising wage dispersion generates more

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individual consumption dispersion and an increased role for government insurance (transfer) programs. The benefits of such transfer programs may be offset by the costs associated with financing through distortionary taxation. We use a political recursive competitive equilibrium concept pioneered in Krusell, et. al. [12]. Specifically, political outcomes are endogenously determined by a median voter who chooses a proportional tax rate that is required to be consistent with a sequential equilibrium of a competitive economy. Obviously, the difficulty in the analysis arises out of the fact that the endogenous policy outcomes and the endogenous evolution of the wealth distribution are interconnected. Idiosyncratic uncertainty greatly complicates the determination of the median voter.

The specific experiment we consider is to calibrate the initial wage process using moments from Heathcote, et. al. [11] in 1983 (a “low” inequality year). Then we re-calibrate the economy to match the increase in the variance of log wages and the decrease in median to mean ratio in 1996 and ask what proportional tax rate the median voter would choose. At this new tax rate, we compute the changes in effective income tax rates by quintile (normalized by the middle quintile). While the sequential median voter model underestimates the changes in effective income taxes by quintile, it does better than that which is predicted by a utilitarian planner.

The main difference from previous work in this area is the introduction of idiosyncratic uncertainty in a political-economy model. For instance, what many consider to be the canonical political economy model by Krusell and Rios-Rull [13] assumes that households are heterogeneous in their earnings but there are complete markets so that there is no uncertainty in the present discounted value of earnings. Complete markets also implies that the differences in initial wealth between households persist indefinitely (i.e. it is possible to choose an exogenous initial wealth distribution that is consistent with a steady state which replicates itself every period from \( t = 0 \) which allows them to identify the median voter ex-ante. In a related paper by Azzimonti et. al. [4], the authors use a first-order approach and show that aggregate state can be summarized by the mean and median capital holdings in a model without uncertainty. They also include a proof that their environment yields single-peaked preferences. The closest paper to ours is Aiyagari and Peled [3]. They consider a model with idiosyncratic uncertainty, however the off-the-equilibrium path beliefs are restricted to be those from the steady state rather than sequentially rational beliefs.

The paper is organized as follows. The data facts are presented in section 2. The model is presented in section 3. In section 4, we discuss how we calibrate the benchmark model. In section 5 we present a quantitative experiment to study the effect of the increase in earnings volatility on tax choices. In section 6 we provide directions for future research. An Appendix contains the algorithm we use to compute the model.

\(^1\)There are several papers which consider a social planner’s utilitarian choice of exogenous taxes with incomplete markets and idiosyncratic uncertainty. See for example, Aiyagari [2] and Domeij and Heathcote [9].
2 Data Facts

It is well documented that there has been an increase in wage inequality during the past three decades. Using the Panel Study of Income Dynamics, Heathcote et al. [11] document in Table 1 of their paper the substantial increase in the variance of the log-wage as well as the decline in the median to mean ratio of wages.\footnote{There are many papers documenting the rise in wage inequality. See, for example, Autor, et al. [5].}

There appear to be two different regimes in Figure 1; one with low variance until the beginning of the 80’s where the mean variance of log wages is around 28% and another regime with high variance from the 1987’s to 1996 with mean variance approximately equal to 39% (an increase of more than 39%). From Figure 2, we observe that during the same period the median to mean ratio displayed a sharp decrease of around 28%. In Section 4, we calibrate our model to their findings.

The Congressional Budget Office (CBO) recently published data on the effective federal tax rates and effective taxes by type (individual income, corporate income, social insurance, and excise tax) for each income quintile of households in the United States for the past two decades.\footnote{The data comes from Table 1A in "Effective Federal Tax Rates for All Households" from http://www.cbo.gov/showdoc.cfm?index=7000&type=1.}

The federal effective tax rate is the sum of all tax types paid by households. The effective tax rate is defined to be the tax liability of a household divided by its post transfer (but pre-tax) income.\footnote{The effective tax rate measures the percentage of household income going to the federal government from taxes. The income measure is comprehensive household income, which comprises pretax cash income plus income from other sources. Pretax cash income is the sum of wages, salaries, self-employment income, rents, taxable and nontaxable interest, dividends, realized capital gains, cash transfer payments, and retirement benefits plus taxes paid by businesses (corporate income taxes; the employer’s share of Social Security, Medicare, and federal unemployment insurance payroll taxes); and employees’ contributions to 401(k) retirement plans. Other sources of income include all in-kind benefits (Medicare, Medicaid, employer-paid health insurance premiums, food stamps, school lunches and breakfasts, housing assistance, and energy assistance). Households with negative income are excluded from the lowest income category but are included in totals. We express the effective tax rate below in terms of the model in equation (17).}

Our analysis abstracts from retirement. Since the main components of social insurance taxes are social security and medicare, we subtract social insurance taxes from total effective federal taxes to obtain our comprehensive measure of redistribution. We will refer to this as the effective tax rate in the remainder of the paper; it is the summation of effective individual tax rates, effective corporate income taxes, and effective excise taxes. One of the important facts that we observe is that redistribution through the tax system in the U.S. has increased after the 1980’s. Figure 3 illustrates the effective tax rates paid by each income quintile (normalized by the effective tax rate paid by the middle income quintile). It is clear from the figure that while the effective tax rate for the higher income quintiles increased relative to that for the middle, the effective tax paid for the lower income quintiles declined relative to that for the middle. For example, the effective tax rate for the highest quintile rose...
from around 2.2 times the value of that paid by the middle quintile in 1979 to around four times it in 2003 (an increase of 81%). At the same time the relative effective tax rate for the lowest quintile decreased by more than 300%.

As an alternative measure of redistribution, we note that after-tax income inequality (i.e. variance of after-tax log income) increased by 7.3% from 1983 to 1996 while pre-tax income inequality increased by 15.3% over that same period.

The relative changes in effective taxes by each quintile we see in Figure 3 could be due to two reasons. First, for given income levels, changes in the tax code may create more redistribution. Second, for a given tax rate schedule, increases in income inequality can generate more redistribution since the tax system is progressive. For example, increases in income of higher quintiles could generate increases in effective taxes because people in those quintiles would be moving up the tax schedule facing higher marginal tax rates. The opposite could happen if lower quintiles experience declines in their income; they move down the tax schedule and face lower marginal tax rates.

To see how these two channels operate, consider a simplified version of the progressive tax system in the US. Let $I_i$ be an income after transfers threshold for income bracket $i \in B$ where $0 < I_1 < I_2 < I_3 \ldots$, let $\tau_i$ be the marginal tax rate for income bracket $i$ where $\tau_1 < \tau_2 < \tau_3 \ldots$, and let $-T^n$ be negative income taxes (e.g. the earned income tax credit). Then we can represent tax liabilities for each income bracket as

$$\text{Tax liability} = \begin{cases} \tau_1 I - T^n & \text{if } 0 \leq I \leq I_1 \\ \tau_2 (I - I_1) + \tau_1 I_1 - T^n & \text{if } I_1 < I \leq I_2 \\ \tau_3 (I - I_2) + \tau_2 (I_2 - I_1) + \tau_1 I_1 - T^n & \text{if } I_2 < I \leq I_3 \\ \ldots \end{cases}$$

Bundling terms, we can rewrite (1) as

$$\text{Tax liability} = \begin{cases} \tau_1 I - T^n & \text{if } 0 \leq I \leq I_1 \\ \tau_2 I - T^n_2 & \text{if } I_1 < I \leq I_2 \\ \tau_3 I - T^n_3 & \text{if } I_2 < I \leq I_3 \\ \ldots \end{cases}$$

where $-T^n_1 = T^n$ and $-T^n_2, -T^n_3, \ldots$ refer to the “intercept” of the tax liability for the corresponding income bracket.

Assuming that there are $N_i$ individuals in income bracket $i$, the effective tax rate for that bracket, denoted $e_i$, is given by:

$$e_i = \frac{\sum_{j \in N_i} (\tau_i I_j - T^n_i)}{\sum_{j \in N_i} I_j} = \frac{\tau_i N_i T_i - N_i T^n_i}{N_i I_i}$$

\footnote{Obviously, this is just an approximation to the more complicated system of taxes and transfers. The way this is written everyone starts with the same negative income tax and then their obligations rise according to their income earnings. Operationally, lower brackets will receive transfers (e.g. if $\tau_1 I < T$) and higher brackets will pay taxes.}

\footnote{The intercept of the tax liability for income bracket $i$ is given by $T^n_i = T^n + \sum_{k=1}^{i-1} (\tau_{k+1} - \tau_k) I_k$.}
Table 1: Changes in Effective Tax Rates by Income Brackets

<table>
<thead>
<tr>
<th>Income Bracket</th>
<th>$%\Delta I_i$</th>
<th>$%\Delta e_i$</th>
<th>$%\Delta (N_i/N)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years 83-97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0 to $10,000</td>
<td>1.6</td>
<td>-53.7</td>
<td>-10.40</td>
</tr>
<tr>
<td>$10,000 to $20,000</td>
<td>-2</td>
<td>-55.8</td>
<td>-8.28</td>
</tr>
<tr>
<td>$20,000 to $30,000</td>
<td>0.8</td>
<td>-13</td>
<td>-9.68</td>
</tr>
<tr>
<td>$30,000 to $40,000</td>
<td>0</td>
<td>-3.2</td>
<td>-8.33</td>
</tr>
<tr>
<td>$40,000 to $50,000</td>
<td>0.22</td>
<td>0</td>
<td>-5.18</td>
</tr>
<tr>
<td>$50,000 to $75,000</td>
<td>0.32</td>
<td>-0.8</td>
<td>0.19</td>
</tr>
<tr>
<td>$75,000 to $100,000</td>
<td>0.7</td>
<td>1.6</td>
<td>17.80</td>
</tr>
<tr>
<td>$100,000 to $150,000</td>
<td>0.92</td>
<td>3.7</td>
<td>43.91</td>
</tr>
<tr>
<td>$150,000 to $200,000</td>
<td>-0.11</td>
<td>8.64</td>
<td>95.46</td>
</tr>
</tbody>
</table>

where $\bar{I}_i$ is average income in bracket $i$. From this expression we can see that the effective tax rate changes if: $\bar{I}_i$ changes (for example, the effective tax rate increases with an increase in $\bar{I}_i$); the tax system ($\tau_i$ and $T^n_i$) changes (for example, the effective tax rate increases with an increase in $\tau_i$ or a decrease in $T^n_i$); and is invariant with respect to changes in the numbers of people $N_i$ in that bracket. Figure 4 shows the total tax liability as a function of income. The slope of the red dotted line gives the effective tax rate for an individual who has income $I$. As can be seen from this figure the effective tax rate increases as income increases even if the tax schedule remains the same.

We now use the above simple framework to argue that the observed fanning out of the effective tax quintiles in Figure 3 is due primarily to changes in the tax structure and not changes in income. Some direct evidence comes from the CBO [8] which reports (p.xiii) that there have been 15 tax bills from 1979 to 1997.\footnote{The Congress enacted 6 major tax bills and many smaller ones changing both the rates of particular taxes and the bases subject to those rates. For example, The Tax Reform Act of 1981, The Omnibus Budget Reconciliation Act of 1990 and 1993 expanded earned income tax credit.} Indirect evidence comes from Table 1 which shows that there has not been a substantial change in average income in each of the brackets between 1983 and 1997 while there has been substantial changes in effective taxes over that time. Moreover, the correlation between the percentage change in average income and the percentage change in relative effective taxes is quite low (0.24). Of course, this does not negate the fact that significant movements in the fractions of people from one bracket to another even if average income in those brackets does not change significantly can in fact lead to significant changes in average income in a given quintile (we provide those movements in the last column of Table 1).

As is clear from Figures 1 through 3, changes in wage inequality may have
important implications for changes in effective tax rates as part of a redistributive or social insurance mechanism. We now turn to a simple incomplete markets model Aiyagari [1] where there is a role for redistribution to illustrate this mechanism.

3 Model

3.1 Environment

There is a unit measure of infinitely-lived households. Their preferences are given by:

\[
E \left[ \sum_{t=0}^{\infty} \beta^t c_t^{1-\sigma} \right],
\]

where \( c_t \) denotes consumption in period \( t \) and \( \beta \in (0, 1) \) is the discount factor. Production takes place with a constant return to scale function, whose inputs are capital and labor:

\[
Y_t = F(K_t, N_t) = K_t^\alpha N_t^{1-\alpha}
\]

where capital letters denote aggregates. The final good can be used for consumption or investment. Capital depreciates at rate \( \delta \).

Each household faces an uninsurable, idiosyncratic labor efficiency shock \( \epsilon_t \in E \) which evolves according to a finite state markov process \( \Pi(\epsilon_{t+1} = \epsilon' | \epsilon_t = \epsilon) \).

Household earnings are given by \( w_t \epsilon_t \) where \( w_t \) is a competitively determined wage. An individual household can self insure by holding \( k_t \) units of capital which pays a risk free rate of return \( r_t \). No borrowing is permitted, which limits the ability of low-wealth households to smooth consumption.

The government taxes household capital holdings and labor income at the same proportional rate denoted \( \tau_t \), consumes \( G_t \) and provides lump-sum transfers denoted \( T_t \). The government is assumed to run a balanced budget so that

\[
G_t + T_t = \tau_t [r_t K_t + w_t N_t].
\]

3.2 Recursive Competitive Equilibrium

Let the joint distribution of capital and efficiency levels across households be denoted \( \Gamma_t(k_t, \epsilon_t) \) with law of motion \( \Gamma_{t+1} = H(\Gamma_t, \tau_t) \). Then the aggregate capital stock is given by

\[
K_t = \int k_t \, d\Gamma_t(k_t, \epsilon_t)
\]

and aggregate labor is given by

\[
N_t = \int \epsilon_t \, d\Gamma_t(k_t, \epsilon_t)
\]

\[8\] Since there are no other assets besides capital, the distribution of capital and the distribution of wealth are identical. We will use these definitions interchangeably.
since preferences are such that households supply their time endowment inelastically. More specifically, given our assumptions, aggregate labor is simply given by

\[ N_t = \sum_{\epsilon_t \in E} \Pi(\epsilon_t) \cdot \epsilon_t (\equiv \tau) \]

where \( \Pi(\epsilon_t) \) denotes the invariant distribution of efficiency levels associated with the markov process \( \Pi(\epsilon_{t+1} = \epsilon|\epsilon_t = \epsilon) \). Perfect competition in factor markets implies

\[ r_t = \alpha K_t^{\alpha-1} N_t^{1-\alpha} - \delta \]

\[ w_t = (1 - \alpha) K_t^\alpha N_t^{-\alpha}. \]

The economy-wide resource constraint in each period is given by

\[ C_t + G_t + K_{t+1} = Y_t + (1 - \delta) K_t \]

Letting \( x \) denote \( x_t \) and \( x' \) denote \( x_{t+1} \), we can write the household problem recursively as

\[ V(k, \epsilon; \Gamma, \tau) = \max_{c,k'} c, k' = u(c) + \beta \sum_{\epsilon'} \Pi(\epsilon'|\epsilon) V(k', \epsilon'; \Gamma', \tau') \]

s.t.

\[ c + k' = k + [r(K)k + w(K)\epsilon] (1 - \tau) + T \]

\[ \Gamma' = H(\Gamma, \tau) \]

\[ \tau' = \Psi(\Gamma, \tau) \]

where the perceived law of motion of taxes is given by \( \tau_{t+1} = \Psi(\Gamma_t, \tau_t) \). The solution to the individual's problem generates decision rules which we denote

\[ c = g(k, \epsilon; \Gamma, \tau) \quad \text{and} \quad k' = h(k, \epsilon; \Gamma, \tau). \]

Before moving to the endogenous determination of tax rates via majority voting, it is useful to state a competitive equilibrium taking as given the law of motion of taxes.

**Definition (RCE).** Given \( \Psi(\Gamma, \tau) \), a Recursive Competitive Equilibrium is a set of functions \( \{ V, g, h, \Gamma, H, r, w, T \} \) such that:

(i) Given \( (\Gamma, \tau, H, \Psi) \), the functions \( V(\cdot), g(\cdot) \) and \( h(\cdot) \) solve the hh's problem in (9);
(ii) Prices are competitively determined (7);
(iii) The resource constraint is satisfied

\[ K' = K^\alpha N^{1-\alpha} + (1 - \delta) K - \int g(k, \epsilon; \Gamma, \tau) d\Gamma(k, \epsilon) - G \]

\[ K' = K^\alpha N^{1-\alpha} + (1 - \delta) K - \int g(k, \epsilon; \Gamma, \tau) d\Gamma(k, \epsilon) - G \]
where $K$ and $N$ are defined as in (5) and (3);

(iv) The government budget constraint (4) is satisfied

(v) $H(\Gamma, \tau)$ is given by

$$
\Gamma'(k', \epsilon') = \int 1_{\{h(k, \epsilon; \Gamma, \tau) = k\}} \Pi(\epsilon' | \epsilon) d\Gamma(k, \epsilon).
$$

### 3.3 Politico Economic Recursive Competitive Equilibrium

In this section, we endogenize the tax choice. In particular, we allow households to vote on next period’s tax rate $\tau'$. Given that households are rational, a decisive voter evaluates the equilibrium effects of her choice, calculates the expected discounted utility associated with each $\tau'$, and chooses the tax rate which gives her highest utility. Since the source of household heterogeneity arises from the idiosyncratic shocks to earnings, we do not know who the median voter is as in the papers of, for instance, Krusell and Rios-Rull [13], we follow an alternative approach.\(^9\) From each household choice we generate the distribution of “most preferred” tax rates and provided each household’s derived utility is single-peaked, the median of the most preferred tax rates is chosen (i.e. it is the Condorcet winner which beats any alternative tax rate in a pairwise comparison). In this case, what the literature usually calls the median voter corresponds to the agent with capital holdings and productivity level that optimally chooses the median tax rate. It is important to appreciate that in environments with idiosyncratic uncertainty the median voter, in general, does not correspond to the agent with median capital holdings or median productivity shock.

To choose the most preferred tax rate, the household must choose among alternatives. Suppose that the household starts with state vector as before $(k, \epsilon, \Gamma, \tau)$ and consider a one period deviation for next period’s tax rate to $\tau'$ not necessarily given by $\tau' = \Psi(\Gamma, \tau)$ while taking as given that all future $(t+2)$ tax choices will be given by the function $\Psi$. In that case, the household’s problem is given by

$$
\tilde{V}(k, \epsilon, \Gamma, \tau, \tau') = \max_{c, k'} u(c) + \beta E_{\epsilon'|\epsilon} [V(k', \epsilon', \Gamma', \tau')]
$$

s.t.

$$
c + k' = k + [r(K)k + w(K)\epsilon] (1 - \tau) + T \quad \Gamma' = \tilde{H}(\Gamma, \tau, \tau')
$$

where $\tilde{H}$ denotes the law of motion for $\Gamma$ induced by the deviation, while all future distributions evolve according to $H$. Note that the future value function $V$ is given by the solution to the household problem in (9) of the definition of a Recursive Competitive Equilibrium. A solution to this problem generates

$$
c = \tilde{g}(k, \epsilon; \Gamma, \tau, \tau') \text{ and } k' = \tilde{h}(k, \epsilon; \Gamma, \tau, \tau').$$

\(^9\)Only in the case of idiosyncratic transitory efficiency shocks are total resources, $(1 + r(1 - \tau))k + w(1 - \tau) + T$, sufficient to know who the median voter is.
It is instructive to understand how the savings choice varies across individual capital holdings and future tax rates for the evolution of the wealth distribution. Note that in Figure 5 higher future tax rates for a given $k$ induce a lower level of savings. More importantly, note that for a high level of future tax rates, low wealth households are borrowing constrained which further compresses the wealth distribution.

The primary reason why a solution to the politico-economic equilibrium is difficult to find is that the tax choice $\tau'$ and associated decision rule $\tilde{h}$ induce a new sequence of distributions:

$$
\Gamma' = \tilde{H}(\Gamma, \tau, \tau')
$$

(11)

$$
\Gamma'' = H \left( \tilde{H}(\Gamma, \tau, \tau'), \tau' \right)
$$

$$
\Gamma''' = H \left[ H \left( \tilde{H}(\Gamma, \tau, \tau'), \tau' \right), \Psi \left( \tilde{H}(\Gamma, \tau, \tau') \right) \right]
$$

... 

Because of this difficulty, Aiyagari and Peled [3] restricted off-the-equilibrium outcomes to be steady states. Specifically, Aiyagari and Peled assume that $\Gamma'' = \Gamma^*(\tau^*)$ where $\Gamma^*$ denotes the steady state distribution corresponding to tax choice $\tau^*$.

Next we define the solution concept.

**Definition (PRCE)** A Politico-Economic Recursive Competitive Equilibrium is:

(i) a set of functions $\{V, g, h, H, \Psi, r, w, T\}$ that satisfy the definition of a RCE;

(ii) a set of functions $\{\tilde{V}, \tilde{g}, \tilde{h}\}$ that solve (10), at prices which clear markets and the govt. budget constraint, and $\tilde{H}$ satisfying

$$
\Gamma'(k', \epsilon') = \int 1_{\{k'(k, \epsilon; \Gamma, \tau, \tau') = k'\}} \Pi(\epsilon'| \epsilon) d\Gamma(k, \epsilon)
$$

with continuation values satisfying (i);

(iii) in individual state $(k, \epsilon)_i$, household $i$’s most preferred tax policy $\tau^i$ satisfies

$$
\tau^i = \psi((k, \epsilon)_i, \Gamma, \tau) = \arg\max_{\tau'} \bar{V}((k, \epsilon)_i, \Gamma, \tau, \tau');
$$

(12)

(iv) the policy outcome function $\tau^m = \Psi(\Gamma, \tau) = \psi((k, \epsilon)_m, \Gamma, \tau)$ satisfies

$$
\int I_{\{k, \epsilon; \tau^m \geq \tau^m\}} d\Gamma(k, \epsilon) \geq \frac{1}{2}
$$

$$
\int I_{\{k, \epsilon; \tau^i \leq \tau^m\}} d\Gamma(k, \epsilon) \geq \frac{1}{2}.
$$

\[^{10}\text{The figure plots } k' = \tilde{h}(k, \epsilon; \Gamma, \tau, \tau') \text{ for } \epsilon = 0.92, \text{ all evaluated at the steady state distribution } \Gamma \text{ associated with } \tau.\]
Condition (iv) effectively defines the median voter. That is, tax outcomes are determined by the voter whose most preferred tax rate is the median of the distribution of most preferred tax rates. To find the median voter, we sort the agents by their most preferred tax rates and then we integrate the distribution of most preferred tax rates over \((k, \epsilon)\) using \(\Gamma(k, \epsilon)\).

For the existence of this type of politico economic equilibrium, preferences need to be single peaked. Single-peakedness simply says that there is an alternative \(\tau^i\) that represents a peak of satisfaction and, moreover, satisfaction increases as we approach this peak. We do not have a general proof of single peakedness; however, we check that in the calibrated economy we solve numerically, the indirect utility function satisfies this property for every \((k, \epsilon, \Gamma, \tau)\) including those off the equilibrium path. Graphically we can see the importance of this condition from Figure 6. There we plot the indirect utility function \(V(k, \epsilon, \Gamma, \tau, \tau')\) over \(\tau'\) for different households \((k, \epsilon)\) evaluated at \(\tau = 0.51\) and the steady state distribution \(\Gamma\) associated with that \(\tau\). Generally, single-peakedness is used to establish that the median ranked preferred tax rate beats any other feasible tax rate in pairwise comparisons so that the median voter theorem applies.

In our environment, the median voter identity is endogenous. In models without uncertainty or with complete markets, an agent with mean capital holdings would choose zero redistribution. However, in our model, even agents with the mean capital holding will vote for a positive tax rate for insurance reasons. A higher government transfer allows agents with low wealth to smooth consumption. There are also general equilibrium considerations. As \(\tau\) increases, the household decision rule implies lower capital accumulation which results in a higher interest rate and lower wage rate. If the latter effect dominates, the distribution will compress.

Finally, we restrict attention to steady state equilibria of the above definition. Specifically,

**Definition (SSPRCE).** A Steady State PRCE is a PRCE which satisfies \(\Gamma^* = H(\Gamma^*, \tau^*)\) and \(\tau^* = \Psi(\Gamma^*, \tau^*)\).

### 3.4 Alternative Mechanisms

We compare our results with three alternative mechanisms. First, we analyze what would be the equilibrium tax rate if it is chosen by sequentially maximizing average welfare, i.e. the solution to a planner’s problem with no commitment. We call it the utilitarian mechanism with no commitment. In this case and identical to the equilibrium considered in the previous section, no restrictions are imposed over the evolution of tax rates. Second, we consider median voter

\footnote{For household \(i\) in individual state \((k, \epsilon)\), and aggregate state \(\Gamma, \tau\), preferences of voter \(i\) are single peaked if the following condition holds: if \(\hat{\tau} \leq \tau \leq \tau^i\) or if \(\hat{\tau} \geq \tau \geq \tau^i\), then \(V((k, \epsilon)_i, \Gamma, \tau) \leq V((k, \epsilon)_i, \Gamma, \hat{\tau})\).}

\footnote{The papers by Azzimonti, et. al. [4] and Basetto and Benhabib [6] have proofs of single-peakedness in nonstochastic environments.}
and the utilitarian mechanisms with commitment, that is where only a one time change in tax rates is allowed. More specifically, tax rates are restricted to be fixed after the first period.

3.4.1 Utilitarian Mechanism with no commitment

The planner sequentially chooses a future tax rate to maximize aggregate welfare. The definition of equilibrium is identical to that of a PRCE but where the condition that defines the equilibrium tax function, condition (iv), is replaced by:

$$\Psi^{un}(\Gamma, \tau) = \arg \max_{\tau'} \int \tilde{V}(k, \epsilon, \Gamma, \tau, \tau') d\Gamma(k, \epsilon).$$

with all continuation values evaluated according to the equilibrium function (e.g. $\tau'' = \Psi^{un}(\Gamma', \tau')$). As before changes in tax rates affect the evolution of the wealth distribution and vice versa.

3.4.2 Mechanisms with commitment

We consider two other tax choice mechanisms with commitment. The first is a simple restriction on the PRCE defined above. In particular, the median voter chooses a future permanent tax rate. It is as if the government can commit to the tax rate. Specifically, the only constraint on problem PRCE is that all continuation values are evaluated according to the “identity” function (that is, $\tau_{t+n+1} = \Psi(\Gamma_{t+n}, \tau_{t+n}) = \tau_{t+n}$, for all $\Gamma_{t+n}$ and $\tau_{t+n}$, $n = 1, 2, ...$ with $\tau_{t+1} = \Psi^O(\Gamma, \tau) = \arg \max_{\tau'} \tilde{V}(\Gamma, \tau', \epsilon)$. Note that in this case we restrict only the evolution of tax rates. The evolution of the joint distribution $\Gamma$ is given by the equilibrium function $H(\Gamma, \tau)$. It is still necessary to compute the entire transition of prices for each possible tax change. We call this case the one-time median voter tax choice.

Even for the one-time voting case, there is a nontrivial transition path for the wealth distribution similar to (11). Specifically, we have

$$\Gamma' = \tilde{H}(\Gamma, \tau, \tau')$$
$$\Gamma'' = H\left(\tilde{H}(\Gamma, \tau, \tau'), \tau'\right)$$
$$\Gamma''' = H\left[H\left(\tilde{H}(\Gamma, \tau, \tau'), \tau'\right), \tau\right]$$

Figure 7 displays the transition paths of aggregate capital for different one-time changes in tax rates.\(^\text{13}\) The starting point is the aggregate capital corresponding to the invariant distribution $\Gamma^*(\tau^*)$ with constant taxes for the initial SS calibration. Higher future tax rate choices $\tilde{\tau} > \tau^*$ imply aggregate capital paths that are monotonically decreasing. Higher future tax rates generate decreases

\(^\text{13}\)This corresponds to point (3.b) in the computational algorithm and the discussion immediately following for one-time tax changes in the appendix.
in individual savings that are reflected in these paths to the new invariant distribution \( \hat{\Gamma}(\hat{\tau}) \) associated with \( \hat{\tau} \). The effects of the tax change disappear slowly (about 50 model periods or years).

To contrast to this mechanism, we consider a one-time utilitarian tax choice. In this case, the planner chooses a future constant tax rate to maximize aggregate welfare:

\[
\Psi^{uc}(\Gamma, \tau) = \arg \max_{\tau'} \int \tilde{V}(k, \epsilon, \Gamma, \tau, \tau') d\Gamma(k, \epsilon).
\]

with all continuation values evaluated according to the “identity” function (e.g. \( \tau'' = \Psi(\Gamma', \tau') = \tau' \forall \Gamma', \tau') \).

4 Calibration

We calibrate the model to the U.S. economy. We can group the parameters in two different sets: (i) preferences and technology \( \{\beta, \sigma, \alpha, \delta\} \); and (ii) the wage generating process \( \{E, \Pi\} \). The first group is set to standard values in the RBC literature. The second set of parameters is calibrated so that the model generates the observed coefficient of variation of wages, the autocorrelation of log-wages, and the median to mean ratio of log-wages in 1983 a year corresponding to the low inequality regime. Once the model is fully calibrated we can perform our quantitative exercise. We re-calibrate only the wage generating process to match the increase in the dispersion of wages and the decline in median to mean wages in 1996. After that we are able to compute the equilibrium tax rate again to answer the main question of the paper, that is how much of the increase in effective the tax rate we can explain with the observed increase in wage inequality.

4.1 Preference and Technology parameters

The first set of parameters are set to standard values for the U.S. economy when using a neoclassical growth type of model. The value of the parameters are displayed in table (2). The time period chosen for the model is four years.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Factor</td>
<td>( \beta )</td>
</tr>
<tr>
<td>Capital Share</td>
<td>( \alpha )</td>
</tr>
<tr>
<td>Preferences</td>
<td>( \sigma )</td>
</tr>
<tr>
<td>Depreciation Rate</td>
<td>( \delta )</td>
</tr>
</tbody>
</table>

\[ \delta = 1 - (1 - 0.06)^4 \]

Table 2: Preferences and Technology Parameters.
4.2 Earnings process

The idiosyncratic uncertainty generated by the labor efficiency shocks is a crucial element because it defines how agents vote over redistribution policies. Since we want to evaluate how the changes in wage inequality affect political outcomes, we calibrate the earnings process to two different points in time: 1983 and 1996.

We set the number of elements in $E$ to three, so $E = \{\varepsilon_1, \varepsilon_2, \varepsilon_3\}$ and we normalize $\varepsilon_2$ to make $\sum_i \pi_i^* \log(\epsilon_i) = 0$ where $\pi_i^*$ is the unconditional probability of $\epsilon_i$ for $i = 1, 2, 3$. We choose the transition matrix to reproduce the moments in the data with the least number of parameters. We set $\Pi$ to

$$\Pi = \begin{bmatrix}
\frac{1-p}{2} & \frac{1-p}{2} & \frac{1-p}{2} \\
\frac{1-p}{2} & \frac{p}{2} & \frac{1-p}{2} \\
\frac{1-p}{2} & \frac{1-p}{2} & \frac{p}{2}
\end{bmatrix}. \tag{13}
$$

Then, the total number of free parameters is three: the transition probability $p$ and two of the labor efficiency levels $\epsilon_1$ and $\epsilon_3$.

The moments we are interested in are:

1. the coefficient of variation of wages

$$C.V. = \frac{Var(\epsilon)}{\bar{\epsilon}^2} = \frac{\sum_i \pi_i^*(\epsilon_i - \bar{\epsilon})^2}{\sum_i \pi_i^* \epsilon_i} \tag{14}$$

2. the yearly autocorrelation of log wages

$$\rho_{\log(\epsilon)} = \frac{\text{Cov}(\log(\epsilon'), \epsilon)}{Var(\log(\epsilon))} \tag{15}$$

3. given that $\pi_1^* + \pi_2^* \geq \frac{1}{2} \geq \pi_1^*$, the median to mean wage

$$\frac{\text{median}(\epsilon)}{\bar{\epsilon}} = \frac{\epsilon_2}{\bar{\epsilon}} \tag{16}$$

Expressions (14)-(16) provide three equations in three unknowns ($\epsilon_1, \epsilon_3, p$) that we use to calibrate the the model. The data provides us with three moments in 1983 and 1996 summarized in Table 3. We associate the 1983 moments with an “initial steady state” and 1996 with a “final steady state”. The final calibrated values and the moments from the data are reported in Table 4.\textsuperscript{14}

This set of parameters implies that $\pi_i^* = 0.33$ for $i = 1, 2, 3$ in the initial and in the final steady states.

\textsuperscript{14}The values of $\text{var}(\log(\epsilon))$, $\frac{\text{median}(\epsilon)}{\bar{\epsilon}}$ are from the Panel Study of Income Dynamics and are taken from Heathcote et.al. [11].
Table 3: Wage Distribution Moments.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial SS</th>
<th>Final SS</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.V.</td>
<td>0.31</td>
<td>0.35</td>
<td>12.15 %</td>
</tr>
<tr>
<td>$E(\epsilon)$</td>
<td>0.878</td>
<td>0.756</td>
<td>-13.89 %</td>
</tr>
<tr>
<td>Autocorrelation (yearly)</td>
<td>0.9</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Wage process parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial SS</th>
<th>Final SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_1$</td>
<td>0.73</td>
<td>0.79</td>
</tr>
<tr>
<td>$\epsilon_3$</td>
<td>1.49</td>
<td>1.58</td>
</tr>
<tr>
<td>$p$</td>
<td>0.835</td>
<td>0.835</td>
</tr>
</tbody>
</table>

5 Quantitative Exercise

To assess the quantitative significance of the change in inequality for changes in effective taxes, we feed $(\epsilon_1, \epsilon_3, p, q)$ parameters calibrated to 1983 moments into the model to deliver a steady state effective tax rate in the initial regime. Then we feed $(\epsilon_1, \epsilon_3, p, q)$ parameters calibrated to 1996 moments into the model to deliver a steady state effective tax rate in the final regime.

After solving the saving decision problem of the household we can solve problem (12) in the definition of PRCE to obtain the tax rate that maximizes each agent’s utility. In Figure 8 we observe the most preferred tax rates as a function of $k$ for different levels of $\epsilon$. The feasible set of tax rates is restricted to the interval $[0, 1]$. For a fixed level of wealth $k$, the function $\tau' = \psi(k, \epsilon, K, \tau)$ is decreasing in $\epsilon$. That is, for a given level of assets, an agent with the lowest productivity $\epsilon_1$ will vote for a higher tax rate than an agent with higher productivity levels $\epsilon_2$ or $\epsilon_3$. This implies that the fraction of households in each productivity level is critical for the determination of the optimal tax rate. High productivity agents receive a larger fraction of their income from wages and are usually saving. On the other hand, the low productivity level agents receive a larger fraction of their income from capital gains and more importantly choose to decrease their capital holdings in equilibrium so have much more to gain from increases in the income tax and the resulting increment in government transfers.

Clearly if two households have equal productivity levels at the time of the tax reform, but different levels of wealth $k$, the wealthier household has more to lose from an increase in tax rates. This effect is seen as a movement along $\tau' = \psi(k, \epsilon, K, \tau)$ for a given $\epsilon$ in Figure 8. The figure shows that the optimal tax rate is decreasing in the level of wealth for a given level of labor productivity. Wealthier agents receive a large portion of their income from the return on capital and therefore changing the tax rate affects the expected net return. In general, this effect offsets the effect of the increase in the government transfers.
mentioned above.

Finally, Figure 8 shows that it is possible for households with two different \((k, \epsilon)\) to choose the same tax rate \(\tau'\) (this is seen as a horizontal slice). For instance, it is evident that a household with \((0.76, \epsilon_2)\) and a household with \((1.42, \epsilon_3)\) choose the same tax rate \(\tau' = 0.4\).

We can summarize the tax choice of a typical agent as follows:

1. For a given \((k, \Gamma, \tau)\), \(\psi(k, \epsilon, \Gamma, \tau)\) is decreasing in \(\epsilon\); that is, a household with a lower wages will choose a higher \(\tau'\).

2. For a given \((\epsilon_i, \Gamma, \tau)\), \(\psi(k, \epsilon, \Gamma, \tau)\) is decreasing in \(k\); that is, a household with a lower wealth will choose a higher \(\tau'\).

3. For a given \((\Gamma, \tau)\), there may be households with different wealth and wages who choose the same \(\tau'\).

To take the theoretical marginal tax rate \(\tau\) to the data, we use the CBO’s definition of effective tax rates, which we denote \(e\). It is defined to be the amount of tax liability divided by pre-tax income including transfers. In the data, the tax liability is reported net of earned income tax credit and this is not included in the transfer measure. That is, from the total transfer \(T\) some fraction \(\phi \in [0, 1]\) is computed as a credit in income taxes and the rest \((1 - \phi)\) is finally distributed as a pure transfer. Thus, for accounting reasons, let \(T^n = \phi T\) denote the earned income credit and \(T^f = (1 - \phi)T\) denote pure transfers. In the context of our model, the effective income tax rate is given by:

\[
e = \frac{\tau \int (rk + w\epsilon) d\Gamma(k, \epsilon) - T^n}{\int (rk + w\epsilon) d\Gamma(k, \epsilon) + T^f}. \tag{17}
\]

The parameter \(\phi\) is calibrated as follows. At the given parameters, \(\{\beta, \sigma, \alpha, \delta, E, \Pi\}\), we obtain the equilibrium marginal tax rate \(\tau\). We then choose \(\phi\) to match the ratio of Total Earned Income Tax Credit to GDP \((\phi T/Y)\) in 1996. The IRS reports that the Total Earned Income Tax Credit is $22.1 billion. Nominal GDP from NIPA tables is $7816.9 billion. To make a fair comparison between the different mechanisms and because each mechanism generates a different marginal tax rate (and transfers), \(\phi\) varies from one mechanism to the other. Specifically, we find \(\phi = 0.0049\) for the sequential mechanism and \(\phi = 0.0058\) for the utilitarian mechanism.

Table (5) presents the changes in effective income tax rates by income quintile when normalized by the middle quintile.\(^{15}\) The model is not capable of matching the big changes that we observe in the data for the lowest and highest quintiles. Surprisingly, the changes in tax rates are very similar between the median voter mechanism and the utilitarian mechanism.

\(^{15}\)Just as in the previous footnote, rising inequality by itself could potentially generate changes in effective tax rates without any change in the marginal tax rate \(\tau\) through the effect of \(\sigma w\) on \(T\) through the government budget constraint. Separated by income quintiles, a change in wage inequality evaluated at the original tax rate can explain between 20 and 35% of the changes in effective income taxes by quintiles. Specifically, it explains 35% of the change of the lowest quintile, 30% of the change in the second quintile, 24% of the change in the fourth quintile and 28% of the change in the highest quintile.
Table 5: Effective Income Tax Rate by Quintile (Normalized by middle quintile)

<table>
<thead>
<tr>
<th>Quintiles</th>
<th>1983</th>
<th>1996</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 (lowest)</td>
<td>0.35</td>
<td>-0.28</td>
<td>-182.9</td>
</tr>
<tr>
<td>Q2</td>
<td>0.67</td>
<td>0.51</td>
<td>-22.9</td>
</tr>
<tr>
<td>Q3 (middle)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Q4</td>
<td>1.27</td>
<td>1.31</td>
<td>2.55</td>
</tr>
<tr>
<td>Q5 (highest)</td>
<td>2.05</td>
<td>2.74</td>
<td>33.9</td>
</tr>
<tr>
<td><strong>Seq. Utilitarian</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 (lowest)</td>
<td>0.83</td>
<td>0.84</td>
<td>0.87</td>
</tr>
<tr>
<td>Q2</td>
<td>0.91</td>
<td>0.89</td>
<td>-2.35</td>
</tr>
<tr>
<td>Q3 (middle)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Q4</td>
<td>1.08</td>
<td>1.11</td>
<td>2.43</td>
</tr>
<tr>
<td>Q5 (highest)</td>
<td>1.16</td>
<td>1.19</td>
<td>2.73</td>
</tr>
<tr>
<td><strong>Seq. Median Voter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 (lowest)</td>
<td>0.82</td>
<td>0.81</td>
<td>-0.33</td>
</tr>
<tr>
<td>Q2</td>
<td>0.90</td>
<td>0.87</td>
<td>-2.93</td>
</tr>
<tr>
<td>Q3 (middle)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Q4</td>
<td>1.09</td>
<td>1.12</td>
<td>2.62</td>
</tr>
<tr>
<td>Q5 (highest)</td>
<td>1.17</td>
<td>1.21</td>
<td>3.33</td>
</tr>
</tbody>
</table>

The increase in wage inequality leads the median voter to choose more redistribution (and insurance). Note that the increase in $\tau$ generates an increase in government transfers but also a decrease in the variance of after-tax income. The inefficiencies associated with the increase in the marginal tax rate are surpassed by the positive effects of redistribution. The greater is the need for insurance the higher are the optimal tax rates under our median voter scheme. As an alternative measure of redistribution and to understand better the results presented in Table (5), the following table displays the percentage changes in pre-tax and after-tax income in the data and those corresponding to the utilitarian and median voter mechanisms.

<table>
<thead>
<tr>
<th>% Change in Pre-Tax Income Inequality</th>
<th>% Change in After-Tax Income Inequality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>15.2</td>
</tr>
<tr>
<td>Median</td>
<td>16.9</td>
</tr>
<tr>
<td>Utilitarian</td>
<td>19.2</td>
</tr>
</tbody>
</table>

There is one key observational difference between our work and the previous political economy models mentioned in the introduction. Models that do not incorporate idiosyncratic uncertainty generate a direct relation between wealth and preferred tax rates; that is, households with more wealth than the median level always vote for lower taxes and the opposite is true for households with
lower than median wealth. On the other hand, as evident in Figure 8, households with different levels of wealth $k$ may vote for the same $\tau'$. Figure 9 shows how agents vote in our model for different levels of wealth relative to the median voter. The figure is constructed as follows. After solving for the optimal tax rate we know the capital holdings of the median voter $k_m$ (as well as his earnings). Then households are sorted based on their level of capital relative to $k_m$ to form two groups: those with $k \geq k_m$ and those with $k \leq k_m$. Finally in each of these two groups, agents are separated between those who prefer a higher tax rate and those who prefer a lower tax rate than the median voter. The figure reports the normalized (relative to the number of households in the $k \geq k_m$ group and the $k \leq k_m$ groups) fraction who prefer higher or lower tax rates. For completeness, we have also provided the distribution of agents over both wealth and earnings levels in the low and high variance steady states in Figures 9 through 12.

The panel on the left of Figure 10 shows the portion of agents with lower wealth $k$ than the median voter. From this group only 72% vote for higher taxes (either those with lower earnings or those with extremely low capital and higher earnings) while 28% vote for lower taxes than the median voter (those with higher earnings). The panel on the right shows the portion of agents with higher capital than the median voter. In this case, only 11% vote for higher taxes (those with lower earnings level) while 89% vote for lower taxes than the median voter (either those with higher earnings or those with extremely high capital and lower earnings). As mentioned before, except for the iid case, total resources $(1 + r(1 - \tau))k + we(1 - \tau) + T$ are not a sufficient statistic for voting decisions.\footnote{\textsuperscript{16}}

5.1 Computed Equilibrium

In this section we present the computed median voter sequential equilibrium for the Final Steady State calibration. We approximated the evolution of the wealth distribution on and off-the-equilibrium by a finite number of moments: mean capital, a measure of the median and the tax rate. In particular, the laws of motion we consider are:

- Law of motion of aggregate capital, function $H$
  \[ K' = a_0 + a_1 K + a_2 z_m + a_3 \tau \]  
  (18)

- Law of motion of median total resources, function $G$
  \[ z'_m = b_0 + b_1 K + b_2 z_m + b_3 \tau \]  
  (19)

- Law of motion of taxes, function $\Psi$
  \[ \tau' = d_0 + d_1 K + d_2 z_m + d_3 \tau \]  
  (20)

\textsuperscript{16}Specifically, in the iid case, if we had sorted on the basis of total resources then the left hand panel would have been 100% voting for higher taxes and the right hand panel would have been 100% voting for lower taxes. Using total resources in the persistent case would have generated a figure similar to that in Figure 8.
where
\[ z_i = k + [r(K)k + w(K)\epsilon_i] (1 - \tau) + T \]  
(21)

In Table (6) we display the parameter values for the laws of motion. The equilibrium income effective steady state tax rate from this sequential equilibrium is 0.357.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(K')</th>
<th>(z')</th>
<th>(\tau')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.15</td>
<td>0.22</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>(3.13E-07)</td>
<td>(4.97E-05)</td>
<td>(7.62E-03)</td>
</tr>
<tr>
<td>(K)</td>
<td>0.70</td>
<td>-0.32</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>(2.99E-05)</td>
<td>(3.14E-04)</td>
<td>(1.29E-02)</td>
</tr>
<tr>
<td>(z)</td>
<td>2.78</td>
<td>0.90</td>
<td>-0.77</td>
</tr>
<tr>
<td></td>
<td>(3.03E-07)</td>
<td>(4.56E-05)</td>
<td>(1.56E-04)</td>
</tr>
<tr>
<td>(\tau)</td>
<td>-2.36</td>
<td>0.04</td>
<td>-0.79</td>
</tr>
<tr>
<td></td>
<td>(1.90E-06)</td>
<td>(2.85E-05)</td>
<td>(3.86E-03)</td>
</tr>
</tbody>
</table>

\(R^2\) 0.9999 0.9999 0.9924

Table 6: Equilibrium Laws of Motion

To illustrate the importance of using another moment like median resources, we solved the PRCE equilibrium without the law of motion (19) and with \(a_2 = 0\) in (18) and \(d_2 = 0\) in (20). Notice that the goodness of fit (measured by \(R^2\)) falls substantially for the law of motion of taxes (20) in Table (7).

<table>
<thead>
<tr>
<th>Variable</th>
<th>(K')</th>
<th>(\tau')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.16</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>(2.99E-05)</td>
<td>(1.16E-02)</td>
</tr>
<tr>
<td>(K)</td>
<td>0.71</td>
<td>-0.89</td>
</tr>
<tr>
<td></td>
<td>(5.16E-06)</td>
<td>(1.26E-02)</td>
</tr>
<tr>
<td>(\tau)</td>
<td>-4.87</td>
<td>-1.72</td>
</tr>
<tr>
<td></td>
<td>(3.15E-04)</td>
<td>(5.32E-01)</td>
</tr>
<tr>
<td>(\tau K)</td>
<td>2.15</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>(3.15E-04)</td>
<td>(5.32E-01)</td>
</tr>
</tbody>
</table>

\(R^2\) 0.9996 0.834

Table 7: Imperfect Equilibrium Laws of Motion
6 Our next iteration

By choosing a 3 state Markov process for efficiency levels, there is not enough variation in earnings to match the income distribution and effective tax rate quintiles. Thus, our next calibration will include at least 5 states. Further we took $G = 0$, but plan to calibrate to actual data in order to also study the levels of effective taxes across regimes.

Another important step will be to include a labor/leisure choice. To this end, we will assume that the period utility function has the form introduced by Greenwood, Hercowitz and Huffman [10]:

\[ u(c, n) = \frac{1}{1 - \gamma} \left[ c - \chi \frac{n^{1+1/\nu}}{1 + 1/\nu} \right]^{1-\gamma} \]

where $\gamma$ is the coefficient of relative risk aversion and $\nu$ is the intertemporal (Frisch) elasticity of labor supply.

The utility function given in equation 22 has the convenient property that the labor supply choice is independent of the consumption-savings choice. In particular, assuming an interior solution, individual labor supply is a simple function of the after-tax labor income:

\[ n = \left[ \frac{w(K, N)\epsilon(1 - \tau)}{\chi} \right]^\nu \]

It is important to note that the optimal labor supply does not depend on household wealth. This property has the useful implication that equilibrium aggregate effective labor supply depends only on the inherited aggregate capital stock, the current tax rate, and the time-invariant distribution over the set of productivity shocks:

\[ N = \left[ \sum_i \pi_i \epsilon_i^{1+\nu} \left( \frac{(1 - \tau)(1 - \alpha)K}{\chi} \right)^{\nu \frac{1}{1+\alpha}} \right]^{\frac{1}{\nu+\alpha}}. \]

This simplifies the solution of our problem because equilibrium prices become a function of the aggregate capital stock and tax rates only (as before).

In the next table, we compute equilibria for both the median voter and utilitarian planner models with commitment.
<table>
<thead>
<tr>
<th>Quintiles</th>
<th>1983</th>
<th>1996</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 (lowest)</td>
<td>0.35</td>
<td>-0.28</td>
<td>-182.9</td>
</tr>
<tr>
<td>Q2</td>
<td>0.67</td>
<td>0.51</td>
<td>-22.9</td>
</tr>
<tr>
<td>Q3 (middle)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Q4</td>
<td>1.27</td>
<td>1.31</td>
<td>2.55</td>
</tr>
<tr>
<td>Q5 (highest)</td>
<td>2.05</td>
<td>2.74</td>
<td>33.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial SS</th>
<th>Final SS</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 (lowest)</td>
<td>0.92</td>
<td>0.91</td>
</tr>
<tr>
<td>Q2</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>Q3 (middle)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Q4</td>
<td>1.06</td>
<td>1.09</td>
</tr>
<tr>
<td>Q5 (highest)</td>
<td>1.09</td>
<td>1.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial SS</th>
<th>Final SS</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 (lowest)</td>
<td>0.90</td>
<td>0.89</td>
</tr>
<tr>
<td>Q2</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>Q3 (middle)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Q4</td>
<td>1.07</td>
<td>1.10</td>
</tr>
<tr>
<td>Q5 (highest)</td>
<td>1.10</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Table 8: Effective Income Tax Rate by Quintile (Normalized by middle quintile)

References


7 Appendix

7.1 Computational Algorithm

We now outline our algorithm for computing equilibria numerically. As in Krusell and Smith [14], we deal with the high dimensionality of the distribution by approximating $\Gamma$ by a finite set of moments. One moment is the aggregate (or mean) capital stock $K$ since this determines prices households face. The other moment is median after-tax income denoted $\gamma$ defined by $(1-\tau)[rk + w\epsilon]$ since this helps forecast the decisive voter and the evolution of the endogenous tax rate. Agents thus perceive the law of motion for $K', \gamma'$ and $\tau'$ to be given by the functions $H(K, \gamma, \tau)$, $G(K, \gamma, \tau)$ and $\Psi(K, \gamma, \tau)$ respectively. Using this approximation we can re-formulate the household problem in an RCE as:

$$V(k, \epsilon, K, \gamma, \tau) = \max_{c, k'} u(c) + \beta \sum_{\epsilon'} \Pi(\epsilon'|\epsilon) V(k', \epsilon', K', \gamma', \tau')$$ (25)

s.t.

- $c + k' = k + (1-\tau)[r(K)k + w(K)\epsilon] + T(K, \tau)$
- $K' = H(K, \gamma, \tau)$
- $\gamma' = G(K, \gamma, \tau)$
- $\tau' = \Psi(K, \gamma, \tau)$

The solution to this problem are the functions $h(k, \epsilon, K, \gamma, \tau)$ and $V(k, \epsilon, K, \gamma, \tau)$.

The one period deviation problem in (10) can be similarly redefined.

$$\bar{V}(k, \epsilon, K, \gamma, \tau, \tau') = \max_{c, k'} u(c) + \beta E_{\epsilon'|\epsilon}[V(k', \epsilon', K', \gamma', \tau')]$$ (26)

s.t.

- $c + k' = k + [r(K)k + w(K)\epsilon](1-\tau) + T$
- $K' = \bar{H}(K, \gamma, \tau, \tau')$
- $\gamma' = \bar{G}(K, \gamma, \tau, \tau')$.

The solution to this problem yields functions $\bar{h}(k, \epsilon, K, \gamma, \tau, \tau')$ and $\bar{V}(k, \epsilon, K, \gamma, \tau, \tau')$.

The distribution $\Gamma$ is a probability measure on $(S, \beta_S)$ where $S = [0, \bar{k}] \times E$ and $\beta_S$ is the Borel $\sigma$–algebra. Thus, for $B \in \beta_S$, $\Gamma(B)$ indicates the mass of agents whose individual state vectors lie in $B$. For reference, here we also defined the operator $\Phi : M(S) \rightarrow M(S)$ where $M(S)$ is the space of probability measures on $(S, \beta_S)$:

$$(\Phi \Gamma)(k', \epsilon') = \int 1_{h(k, \epsilon, K, \gamma, \tau) = k'} \Pi(\epsilon'|\epsilon) d\Gamma(k, \epsilon).$$ (27)

An SSPRCE must be contained in the following set of stationary equilibria. Let $\tau_j \in \{\tau_1, ..., \tau_J\}$ be a grid of tax rates in $[0, 1]$ and let $\Gamma^{*\ast}(\tau_j)$ be
an associated stationary distribution which solves RCE for \( \tau' = \tau = \tau_j \). This procedure generates a set of stationary distributions and associated tax rates \( SS = \{ \Gamma^{ss}(\tau_j), \tau_j \}_{j=1}^{J} \). Simply put, this is like solving for the steady state of an Aiyagari [1] model for a grid of exogenous constant taxes.

1. Let \( \Psi^n(K, \gamma, \tau) \) be the tax function at iteration \( n \). For \( n = 1 \), we set this equal to a constant.

2. Given \( \Psi^n(K, \gamma, \tau) \), solve a RCE. That is, let \( H^s(K, \gamma, \tau) \) and \( G^s(K, \gamma, \tau) \) be the functions associated with the law of motion for aggregate capital and median after tax income at iteration \( s \). For \( s = 1 \) we set these to a constant.

   (a) solve for household decision rules (in particular saving \( h^s(k, \epsilon, K, \gamma, \tau) \)) in problem (25).

   (b) use the operator \( \Phi \) defined in (27) and \( \Psi^n(K, \gamma, \tau) \) to generate a joint sequence of transitional distributions \( \Gamma_{n} \) and tax rates \( \tau_{n} \) for \( n = 1, ..., \Upsilon \) starting from \( \Gamma_{0} = \Gamma^{ss}(\tau_j) \) and \( \tau_{0} = \tau_j \) for each of the \( j = 1, ..., J \) possible tax rates. We take \( \Upsilon \) large enough to ensure that \( (\Gamma_{\Upsilon}, \tau_{\Upsilon}) \in SS \).

   (c) Use the \( J \) sequences of transitional distributions and taxes \( \{ \Gamma_{n}, \tau_{n} \}_{n=1}^{\Upsilon} \) to generate a sequence of \( \{ K_{n}, \gamma_{n}, \tau_{n} \}_{n=1}^{J \times \Upsilon} \). Run a linear regression on this sequence to update \( H^s \) and \( G^s \) as in Krusell and Smith [14]. If the updated \( H^s \) and \( G^s \) are close enough to the previous iteration, go to step 3, otherwise set \( \Upsilon = \Upsilon + 1 \) and go to step 2 with the updated functions.

3. Solve a PRCE.

   (a) From step 2, we know \( V(k, \epsilon, K, \gamma, \tau) \) which depends on \( \Psi^n(K, \gamma, \tau) \) since it is in the constraint set in (25). Given this, we solve the one period deviation problem (26) starting from \( \Gamma_{0} = \Gamma^{ss}(\tau_j) \) and \( \tau_{0} = \tau_j \) for each of \( j = 1, ..., J \) in order to generates \( \tau_1 \). Using the operator \( \Phi \) evaluated at decision rules \( h(k, \epsilon, K_{0}, \gamma_{0}, \tau_{0}, \tau_{1}) \) obtain \( \Gamma_{1} \) where \( K_{0} \) and \( \gamma_{0} \) are obtained from \( \Gamma_{0} \). The next period’s distribution and tax rate, \( (\Gamma_{2}, \tau_{2}) \), are obtained by repeating the same steps starting at \( (\Gamma_{1}, \tau_{1}) \). Continue in this way to compute the transitional sequence \( \{ \Gamma_{n}, \tau_{n} \}_{n=1}^{\Upsilon} \).

   (b) Use \( \{ \Gamma_{n}, \tau_{n} \}_{n=0}^{\Upsilon} \) to generate the sequence \( \{ K_{n}, \gamma_{n}, \tau_{n} \}_{n=1}^{J \times \Upsilon} \). Run a linear regression on this sequence to update \( \Psi^n \). If the updated \( \Psi^n \) is close enough to the previous iteration, go to step 4, otherwise set \( n = n + 1 \) and go to step 1 with the updated functions.
4. Having solved for the functions $H, G$, and $\Psi$, solve for steady state $K^*, \gamma^*$, and $\tau^*$ that solves the three equations:

\begin{align*}
K^* &= H(K^*, \gamma^*, \tau^*) \\
\gamma^* &= G(K^*, \gamma^*, \tau^*) \\
\tau^* &= \Psi(K^*, \gamma^*, \tau^*) .
\end{align*}

One-time voting simply restricts $\tau_\eta = \tau_1$ for all $\eta > 1$ in step 3a and uses (25) to generate the sequence $\{\Gamma_\eta, \tau_\eta\}_{\eta=0}^T$ with $\tau_\eta = \tau_1$ for all $\eta > 1$. 
8 Figures


Figure 1: Increase in wage inequality 1966 – 1996.

Figure 2: Decrease in median to mean ratio of log wages 1967 – 1996.
Source: Congressional Budget Office.

Figure 3: Effective Income Tax Rate by quintiles 1967 – 1996.
Tax Liability and Effective Tax Rate as a Function of Income

Figure 4: Progressive Tax System
Figure 5: Decision rules over wealth for different levels of $\tau'$. 
Figure 6: Single Peaked Preferences.
Figure 7: Transitions at initial steady state $\tau$
Figure 8: Most Preferred Tax Rate.
Figure 9: Cross-Section Distribution Initial SS.

Figure 10: Distribution by Wealth Quintiles Initial SS.
Figure 11: Cross-Section Distribution Final SS.

Figure 12: Distribution by Wealth Quintiles Final SS.
Figure 13: Distribution of Wealth and Tax Choices.