Marginal Tax Rates and the Tax Reform Act of 1986: the long-run effect on the U.S. wealth distribution

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Abstract

I investigate the effects of the Tax Reform Act of 1986 on the U.S. wealth distribution in a model in which heterogeneous agents face idiosyncratic labor income risk and hold only one asset. The model's stochastic process for earnings is consistent with estimates from panel data. I calibrate the model to match the U.S. wealth distribution and the progressive U.S. income tax structure before and after the reform. The reform increases the after-tax return to savings more for wealthy households than for wealth-poor households. As a result, I find that the tax reform can account for all of the increase in wealth inequality observed in the data.

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It is well known that there were large changes in the U.S. personal income tax structure in the 1980s. Altig and Carlstrom (1999) have shown that changes in marginal tax rates as a result of the Tax Reform Act of 1986 can account for a significant portion of the increase in income inequality during the late 1980s. At the same time, Wolff (1994) and Weicher (1995) report that *wealth* inequality increased in the 1980s. Based on these observations, I pose a simple question: how did the changes in the personal income tax structure associated with the Tax Reform Act of 1986 affect the long-run U.S. wealth distribution?

Several authors have studied the role of fiscal policy on wealth inequality. Castañeda et al. (1998) considers the effect of moving from progressive to proportional income taxation. Domeij and Heathcote (2000) study the effects of switching from capital to labor income taxation. De Nardi (1999) investigates the consequences of abolishing estate taxes. The contribution of this paper is that it is the first to evaluate the effect of an historical policy change on the wealth distribution, as opposed to the implications of alternative purely hypothetical tax systems. The paper therefore contributes towards a positive theory of changes in wealth inequality.

I construct a heterogeneous agents model with borrowing constraints and uninsurable idiosyncratic shocks to income along the lines of Huggett (1993) and Aiyagari (1994). The model is calibrated to match features of the wealth distribution and tax structure of the U.S. economy in 1984. Then I recompute the stationary equilibrium of an economy with the same stochastics process for earnings, but this time using the post-TRA86 tax structure of 1989. The idea is to compare the long-run (stationary) wealth distribution under the 1984 tax structure to the long-run wealth distribution under the 1989 tax structure. Any changes in my model's wealth distribution will be generated endogenously by behavioral responses of savings (asset holdings) to changes in the tax code.

I find that modeling the tax reform at lower levels of the income distribution is critical for this experiment, since most U.S. households have income well below the mean of the income distribution.

Facts on the Wealth Distribution. Table 1 shows Wolff's (1994) calculations of the distribution of net worth[2] in 1983 and 1989 using data from the Survey of Consumer Finances (SCF). Table 2 shows Wolff's calculations (also from the SCF) of the distribution of income[3] in the same years. As noted in Díaz-Giménez et al. (1997) and elsewhere, the U.S. distribution of wealth is much more unequal than the distribution of income. By Wolff's calculations, the wealthiest 1% of U.S. households hold about a third of total U.S. wealth, whereas households in the upper 1% of the income distribution receive only about 16% of total U.S. income.

Wolff finds that wealth inequality increased significantly in the U.S. from 1983 to 1989, with the top 0.5% of households seeing the largest percentage gains, and the bottom 80% of households (ranked by net worth) losing ground in percentage terms (see Table 1). Wolff finds that the Gini index of the wealth distribution increased from 0.80 in 1983 to 0.84 in 1989. Weicher (1995) also computes Gini indexes from the 1983 and 1989 SCFs and finds that the changes in the wealth Gini indexes are

[2] Wolff defines household net worth as: gross value of owner-occupied housing, other real estate owned by household, cash and demand deposits, time and savings deposits, certificates of deposit, money market accounts, government bonds, corporate bonds, foreign bonds, other financial securities, cash surrender value of life insurance plans and pension plans, IRAs, Keoughs, corporate stock, including mutual funds, net equity in unincorporated businesses, and equity in trust funds minus mortgage debt, consumer debt, and other debt.

[3] Household income is total pre-tax household income reported by the survey respondent. Note that the top 10% of households in Table 1 are not the same as the top 10% of households in Table 2, as rankings differ significantly depending on whether the ranking is by wealth or income (see Díaz-Giménez, et al. 1997).

statistically significant. He finds that the change in the Gini index from 1983 to 1989 is about 2 per cent for various measures of wealth.

For the purposes of my paper, Wolff's and Weicher's calculations of *changes* in the distribution of wealth are meant to be merely suggestive. I am not attempting to match the wealth distribution in *both* 1983 *and* 1989, for several reasons. First, we know that there were many changes in the economy between 1983 and 1989 which might have affected the wealth distribution apart from the changes in the federal tax structure. For example, there were large changes in equity prices in the 1980s. Since households with different wealth levels hold very different portfolios (Kennickell and Woodburn (1997); Kennickell, et al. (2000)), we would expect these changes in asset prices to change the distribution of wealth. Other factors unrelated to tax reforms, such as a growing gap between returns to high- versus low-skill labor, also account in part for an increase in pre-tax and pre-transfer income inequality (see Levy and Murname [1992]). Since I am abstracting from these changes in the economy in the 1980s, I should not expect to match the wealth distribution exactly in both 1983 and 1989. The second reason I am not attempting to match the wealth distribution in both years is related to computational difficulty: I am only calculating stationary equilibria before and after the tax reform. It should be possible to calculate the transition path from one stationary equilibrium to the other, but it is computationally much more expensive. To the extent that it takes more than six years (six periods in the model) to transition from one stationary equilibrium to the other, I should not expect to match the wealth distribution seen in the data in both years. For these reasons I calibrate the model to match the wealth distribution data in only one year (1984), and then perform the policy experiment of switching to the post-reform tax structure of the other year (1989). Having said that, Budría et al.'s calculations from the 1992 and 1998 SCF's show almost no change in wealth inequality over the 1990's. Budría et al.'s calculations are in line with calculations of Kennickell (2000) from the 1989, 1992, 1995, and 1998 SCF's, which also show virtually no change in the wealth Gini over the period 1989 to 1998.

The Tax Reform Act of 1986. Slemrod (1990, pp. 2-3) summarizes TRA86 as follows:

> Its theme was to lower the statutory rates of tax and to recover the revenue thereby lost by broadening the tax base....On the individual side, both the standard deduction and personal exemption allowance increased significantly and tax rates were reduced, most dramatically at the top of the income distribution where the marginal rate fell from 50 percent to 28 percent.

Slemrod goes on to argue that the efficiency gains of the tax reform were small, but that we should focus more attention on the distributional effects of the reform.

In this paper, I will be able to capture the changes in marginal tax rates applied to personal income, as well as the changes in deductions and personal exemptions. However, there are other aspects of tax reform of 1986 which I will not model. There were large changes in the corporate income tax. Slemrod (1990) points out that the basic corporate tax rate was reduced from 46% to 34%, but the investment tax credit was eliminated and depreciation schedules were slowed. In fact the net effect was that corporate taxes increased from 8.5% of federal revenue in 1984 to 10.4% in 1989. Although Slemrod and others point out that the reform was designed to decrease the percentage of total federal revenue collected from personal income taxes, *ex post* personal income taxes *increased* from 44.8% of federal revenue in 1984 to 45.0% in 1989 (data from the U.S. Bureau of Economic Analysis, reported in Slemrod and

Bakija, 2000, table A.3, p. 272)[4] On the other hand, average marginal tax rates on personal income decreased from 1984 to 1989[5].

The Model

The model is an extension of Huggett (1993) to a distorted economy with capital accumulation. There is a continuum of infinitely-lived households. In each period each household receives a shock to its labor productivity ε_t. Each household's shock follows a Markov process with stationary transition probability $\pi(\varepsilon'|\varepsilon) = Prob(\varepsilon_{t+1} = \varepsilon'|\varepsilon_t = \varepsilon)$ for $\varepsilon', \varepsilon \in \{\varepsilon_l, \varepsilon_m, \varepsilon_h\}$. Each household's shock is independent of all other households' current and past shocks. Since we have a continuum of households, a Law of Large Numbers applies, so that there is no aggregate uncertainty.

Household's problem. Each period each household chooses consumption c_t and next-period asset holdings a_{t+1} to solve the following problem:

$$V(a,\varepsilon) = \max_{c,a'} \left\{ u(c) + \beta \sum_{\varepsilon'} v(a',\varepsilon')\pi(\varepsilon'|\varepsilon) \right\}, \tag{1}$$

subject to:

c $\leq a + \varepsilon wn - a'q - \tau(y - d(y)) + z$,

$c \geq 0$,

$a' \geq \underline{a}$

[4]In same table, Slemrod and Bakija report that total federal tax revenue as a percentage of GDP increased from 19.1% in 1984 to 19.8% in 1989. Corporate and personal income tax revenue as a percentage of GDP both increased, and social insurance taxes decreased as a percentage of GDP.

[5]Using a Barro and Sahasakul's (1983,1986) definition of marginal statutory income tax rates, and using shares of AGI as weights, Stephenson (1998) finds that average marginal statutory income tax rates decreased from 27.2% in 1984 to 23.4% in 1989. Using Seater's (1982,1985) definition of effective marginal income tax rates, Stephenson still finds a decrease in average marginal income tax rates from 19.6% in 1984 to 17.5% in 1989. While Seater (1982) computes average marginal corporate taxes over the period 1909 to 1975, I am unaware of any work that computes average marginal corporate tax rates over the 1980s.

$q = \frac{1}{1+r}$

$y = ar + \varepsilon wn + z,$

$u(c) = \frac{c^{1-\mu}}{1-\mu}$

where ε is the labor productivity shock, w is the wage rate, n is the exogenous labor supply, q is the price of next-period asset holdings, $\tau(y)$ is income tax, y is household income, $d(y)$ represents deductions as a function of income, z is a (lump-sum) transfer from the government, and r is the risk-free interest rate. The Euler equation is as follows:

$$u'[c]q \geq \beta E \left\{ u'[c'][1 + r(1 - \tau'(\cdot)(1 - d'(y')))] \right\}, \tag{2}$$

with equality if $a' > \underline{a}$ The solution to the household's problem gives optimal decision rules $a(a, \varepsilon; q, w)$ and $c(a, \varepsilon; q, w)$. The presence of the borrowing constraint causes the household to exhibit precautionary saving. However, as noted in Aiyagari (1994), precautionary saving is not quantitatively important in this class of models[6].

Firms. The economy also has identical perfectly competitive firms that convert capital (K) and labor (L) into output (Y). $Y = f(K, L) = K^{\alpha}L^{1-\alpha}$, where α is capital's share. The households' asset holdings represent claims on physical capital, so that the sum of all asset holdings in the economy is equal to the aggregate stock of capital. Capital depreciates at rate δ. In this setup with exogenous labor supply, aggregate labor L is : L=$\sum_i p_{\varepsilon_i}\varepsilon_i n$ where p_{ε_i} is the (stationary) fraction of households with labor productivity shock i.

Government. In my benchmark case, I follow Altig and Carlstrom (1999): the

[6]We may define aggregate precautionary saving as the difference between equilibrium asset holdings and the value for asset holdings that would equate the marginal product of capital with the rate of time preference. Under this definition, in my benchmark parameterization only about 8% of asset holdings are due to precuationary saving.

government collects income taxes from each household, and rebates the same amount that it collected from a household back to that household. That is, for each household i:

$$\tau(y_i - d(y_i)) = z_i \tag{3}$$

Thus in the model households are myopic in that they take these transfers as lump-sum. I make this implausible modeling assumption because I want to focus on the distortionary implications of the reform rather than the direct redistributive effects. That is, I am not modeling some important aspects of the tax reform, e.g. changes in corporate taxes and capital gains taxes. To the extent that my model captures the direct redistributive effects of decreases in personal tax rates but not the (counteracting) redistributive effects from increases in corporate tax payments, my results would be biased towards predicting large changes in the wealth distribution. Modeling transfers as I do in equation (3) allows me to focus on changes in the distortionary aspects of the marginal tax rates. Modeling transfers in this way also aids comparison with Altig and Carlstrom's results, since this is how they model transfers. In the sensitivity analysis section (below), I will modify this modeling assumption so that all households receive the same lump-sum transfer.

Taxes. The tax function is the one constructed by Altig and Carlstrom (1999), with one important modification (see figure 1). The tax function is also described in more detail under the calibration section.

Equilibrium: At any point in time, different households can have different asset holdings and labor endowments shocks (a and ε). The state space is defined as $X = A \times E$, where $A = [\underline{a}, \infty)$ and $E = \{\varepsilon_l, \varepsilon_m, \varepsilon_h\}$. Let Ψ be a probability measure on (S, β_S), where $S = [\underline{a}, \overline{a}] \times E$, β_S is the Borel sigma-algebra on S, $\underline{a}$ is the (exogenous) borrowing constraint, and $\overline{a}$ is an endogenous upper bound on assets. For $B \in \beta_S$, $\Psi(B)$ is the mass of households whose individual state vectors (a, ε) are in B.

In order to define the equilibrium, we need another tool: a *transition function* P maps $S \times \beta_S$ into $[0,1]$. $P((a,\varepsilon), B)$ is the probability that a household with state vector (a, ε) will have a state vector in B next period. A probability measure Ψ is stationary when:

$$\Psi(B) = \int_S P((a,\varepsilon), B) d\Psi, \qquad \forall B \in \beta_S \tag{4}$$

Definition of Equilibrium: A stationary equilibrium for this economy consists of allocations $\{c(a,\varepsilon), a'(a,\varepsilon), K, L, z(y)\}$, prices $\{r, w, \tau(y)\}$ and a probability measure Ψ such that:

1. $c(a,\varepsilon)$ and $a'(a,\varepsilon)$ are optimal decision rules, given q.

2. Input markets are competitive:

   $w = f_2(K, L)$, and $r = f_1(K, L) - \delta$

3. Asset, goods, and labor markets clear:

$$\int_S a(a, \varepsilon; q, w) d\Psi = K \tag{5}$$

$$\int_S c(a, \varepsilon; q, w) d\Psi + \delta K = f(K, L) \tag{6}$$

$$L = \int_S \varepsilon n d\Psi \tag{7}$$

4. The government's budget constraint is satisfied:

$$\int_S z(y) d\Psi = Z = T = \int_S \tau(y) d\Psi \tag{8}$$

5. Ψ is a stationary probability measure satisfying equation (4).

Under standard assumptions a stationary equilibrium exists (see Aiyagari [1994]). The appendix covers an algorithm for solving the model. The algorithm is a modification of the one used by Huggett (1993).

Calibration

I use the tax functions constructed by Altig and Carlstrom (1999), with one important modification. For 1989, Altig and Carlstrom (A-C hereafter) use the actual marginal tax rates applied to adjusted gross income (AGI) in 1989, which reflects the fully phased-in changes introduced by TRA86. The statutory rates are taken from Schedule Y for married persons filing jointly in tax years 1989 and 1984, with two adjustments (described below)[7].

As A-C point out, these tax functions exclude many forms of tax avoidance. However, they do incorporate personal exemptions and deductions by estimating a piecewise linear "deductions function" $d(y)$, where y is income. The statutory marginal tax rates are applied to income after deductions and exemptions. A-C also adjust the 1984 schedule for real income growth between 1984 and 1989. When applying the tax functions in the model, I scale household income so that average income in the model is equal to the average 1984 Adjusted Gross Income in A-C's data. A-C's tax function obviously does not capture changes in corporate taxes or in realized long-term capital gains taxation, both of which were important aspects of the reform[8].

[7]The statutory rates for Schedule Y in 1989 include only a 15% rate and a 28% rate. However, a phase-out of deductions and exemptions creates an effective statutory rate of 33% over the phaseout range.

[8]Hausman and Poterba (1987) calculated that 5.9 million households would be removed from the federal tax rolls as a result of changes in the personal exemption and the expansion of the

There is a debate going back at least to Seater (1982, 1985) and Barro and Sahasakul (1983, 1986) about when the appropriate measure of marginal tax rates is an effective one (estimated from the data) or the statutory marginal rates. Seater (1982, 1985) uses effective marginal rates. Effective marginal rates compute the marginal change in taxes paid per marginal dollar of income. Barro and Sahasakul (1983) argue that computing marginal rates from the data in this way underestimates the appropriate marginal tax rates. As income increases, deductions from taxable income also increase. (Altig and Carlstrom's estimates of deductions as a function of income confirm this intuition.) Calculating the marginal change in taxes paid as a function of income will capture marginal changes resulting from changes in deductions per marginal unit of income. To some extent (particularly at higher levels of income), deductions are the result of choices of one type of consumption (e.g., tax-deductible gifts to charity) over another (e.g., non-tax-deductible gifts to one's spouse). For the purposes of this paper, I only want to capture the marginal tax rate τ which applies to the marginal rate of substitution between consumption today and tomorrow. We may think of statutory marginal income tax rates as an upper bound on τ and effective marginal tax rates estimated from the data as a lower bound. I take a middle-of-the-road approach: I use the statutory marginal tax rates, but since I am not modeling intratemporal consumption choices (e.g., between gifts to spouse or gifts to charity) I also take into account the effect of marginal deductions on the marginal tax rate. This marginal deduction rate is the one estimated by Altig and Carlstrom from the

Earned Income Tax Credit (EITC) as a part of TRA86. My model includes a zero marginal tax rate for households with income less than the standard deduction. Therefore the model will capture households dropped from the rolls because of the increase in the standard deduction. However, the expansion of the EITC is not captured in Altig and Carlstrom's tax data. On the other hand, the phaseout of the EITC created an effective marginal tax rate of 25% for people who faced the regular marginal tax rate of 15% and were also in the EITC phaseout range.

Statistics of Income data. The marginal tax functions I use in the benchmark cases are shown in Figure 1. Figures 4 and 5 compare my tax functions to those of Altig and Carlstrom. Since the deductions function is piecewise linear, taking into account the marginal increase in deductions for a marginal increase in income lowers the effective marginal tax rate proportionally.

Modeling marginal tax rates in this way allows me to capture an important aspect of the tax reform. The statutory marginal personal income tax rates actually increased at certain levels of income (see Figure 1). Previous work on statistically estimated tax functions by Gouveia and Strauss (1994) assumed a particular (smooth) functional form, which does not allow the marginal tax function to cross at two points so low in the income distribution. Figure 2 shows my marginal tax functions plotted on the same graph as the cumulative distribution function of income for A-C's data as well as for my model. In my model about 63.3% of households faced an increase in their marginal tax rates as a result of the reform(see Figure 2)[9]. Therefore, when analysing the effects of the tax reform on inequality, it is important to capture this region of the marginal tax function accurately.

To calibrate the household productivity process I use a modification of the procedure used by Domeij and Heathcote (2000). Broadly speaking, we want to match two features of the data: (i) the amount of wealth inequality and (ii) the uncertainty which households faces in their earnings process. In order to meet the first criterion, I choose 5 target statistics of the wealth distribution: the asset holdings of the upper 1% of households, the top 10%, the top 20%, the bottom 60%, and the Gini index of wealth. Wolff (1994) reports that in 1983 the top 1% of households (ranked by net

[9]Using the cumulative distribution function from A-C's data and A-C's tax functions, 64.5% of households faced higher marginal tax rates as a result of the reform.

worth) held 33.7% of total wealth. Wealthy households also tend to have high income and thus face high marginal tax rates. Significant changes in the wealth distribution as a result of TRA86 are likely to come from behavioral responses of wealthier households[10]. Thus it is important for my purposes to closely match the upper end of the wealth distribution.

Since wealth inequality in this model is driven by uncertainty in the earnings process, it is also important that my earnings process match estimates of the earnings uncertainty seen in the data. Accordingly, following Domeij and Heathcote I choose parameter values to match two more targets: the first-order correlation coefficient (ρ) and the standard deviation (σ) of the productivity process. Citing Card (1991) (who uses 1969-1979 PSID data), Flodén and Linde (1999) (who use 1988-1992 PSID data), and Storesletten, Telmer, and Yaron (1999) (who use 1969-1992 PSID data), Domeij and Heathcote report estimates for ρ in the range 0.88 to 0.96 and estimates for σ in the range 0.12 to 0.25. Storesletten et al.'s estimates for ρ and σ are, respectively, 0.935 and 0.13. The earnings process I chose produces a ρ equal to 0.929 and a σ equal to 0.125 and also matches statistics of the wealth distribution[11]. (Details of the calibration procedure are given in the appendix.) Thus my parameter estimates

[10] Díaz-Giménez, et al., using 1992 SCF data, report that the correlations between income and wealth are 0.321.

[11] Table 7 (rows 4 and 5) reports the results of increasing the spread of high and low states of the labor-productivity shocks while holding the mean of the shocks constant. These results are for the parameterization of the productivity process used in an earlier version of the paper (specifically, the parameterization used by Domeij and Heathcote [2000]). However, the qualitative results of the sensitivity analysis should follow through. The aggregate capital stock increases, the wealth distribution becomes more equal, and the wealthiest households become less wealthy. The intuition is as follows. A mean-preserving spread is an increase in the absolute risk facing the households. Constant relative risk aversion implies decreasing absolute risk aversion. Wealth-poor households have higher absolute risk aversion and thus they save more to insure against low values of the shock. Aggregate savings increases and thus the interest rate falls. For wealthy households, the effect of the fall in the interest rate is more important than the increased risk, so wealthy households save less than before.

are very close to Storesletten et al.'s, whose data overlap my period of interest. It is important to note here that I am trying match the uncertainty in the earnings process, since that is what is driving wealth inequality. I am not necesarrily trying to match all of the earnings inequality seen in the data. In estimating their earnings process, Storesletten et al. control for education, age of household head, and measurement error. They also divide each household's total earnings by the number of household members. All of these features of their process are appropriate for my model, which abstracts from the life cycle, human capital, and differences in household size. We would expect education, age of household head (a proxy for work experience), and family size to affect overall earnings inequality in the PSID data. Since my model's earnings process is calibrated to match Storesletten et al.'s process, which controls for education, etc., we should not expect earnings inequality in my model to match overall earnings inequality in PSID data[12].

For the discount factor β I choose a standard parameter value of 0.96. In the benchmark model with β equal to 0.96 and the 1989 tax structure, the capital to GDP ratio is 2.67. In the data I find that the 1989 per household capital to GDP ratio is 3.46[13]. I find that when β equals 0.99 the model matches the capital to GDP ratio more closely. However, values for β in the range 0.96 to 0.99 produce virtually the same wealth inequality in the model[14].

[12]In a richer model that incorporated differences in age, human capital, and household size, the mechanism that drives changes in wealth inequality in my model–namely differences in the after tax return to saving at different levels of income–would still be operative.

[13]The 1989 Survey of Consumer Finances reports a mean family wealth of $183,700 in 1989 dollars. According my calculations using the 1998 Economic Report of the President, the 1989 per household GDP was $52,992. The 1998 Economic Report of the President reports a U.S. population of 247.342 million in 1989. According to Table B-1 of the same report, the nominal GDP in 1989 was $5,438.7 billion. I divide the population by the average household size 2.41 in the Survey of Consumer Finances, and then divide the 1989 nominal GDP by the result to obtain the GDP per household.

[14]I chose values for β of 0.99 and 0.90. With β equal to 0.99, the model's capital to GDP ratio was

I set the coefficient of relative risk aversion μ equal to 1, which is within the standard range in this literature[15].

All of the parameter values and their sources are listed in Table 3.

Results and discussion

Row 1 of Table 4 reports the model's wealth distribution under the 1984 tax structure. The table shows that the model matches the wealth distribution in the data well. Furthermore, my model produces a realistic wealth distribution using an earnings process which is consistent with estimates of variability and persistence of the earnings process estimated from PSID data. For comparison, Table 5 reports wealth distribution statistics for Castañeda et al.'s (2000) model. Castañeda et al. use an earnings process which has (after the appropriate normalization) a coefficient of correlation (ρ) of 0.32 and a standard deviation (σ) of 1.36, which are far from the range of estimates from panel data[16]. Even Heaton and Lucas (1996), who allow for permanent but unobservable household specific effects, find a ρ of 0.53 and a σ of 0.25.

Row 2 of Table 4 shows the result of switching to the 1989 tax structure. The model indicates that changes in the personal income tax structure resulting from the 1986 tax reform, other things equal, would make the stationary distribution of wealth significantly more unequal, with the wealth Gini increasing from .790 to .858. The tax reform (or at least the aspects of the tax reform which I model) lowered

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indeed higher (and closer to the one in the data), at 3.53. However, the wealth Gini was virtually the same, at 0.859, compared to 0.858 in the benchmark case (see row 2 of table 4 for the benchmark case). Setting β equal to 0.90, the model produces a much lower capital to GDP ratio of 1.62, and the wealth Gini is significantly higher than in the benchmark case at 0.928.

[15] I report results for sensitivity analysis of μ in Table 7. Increasing risk aversion makes the wealth distribution more equal.

[16] Castañeda et al. are not attempting to match an earnings process estimated from PSID data. Instead they attempt to match estimates of earnings inequality from SCF data.

the marginal tax rates for high-income households, and thus increased the return to savings for those households. High income households also tend to be wealthy households[17]. Since wealthier households own the majority of capital, aggregate capital in the model increases, driving down the before-tax interest rate. This decrease in the before-tax interest rate, combined with an increase in the marginal tax rate for *some* of the wealth-poorest households, decreases the return to savings for wealth-poor households. As a result of these changes in equilibrium returns to savings, stationary equilibrium wealth inequality increases in the model.

The next two rows of Table 4 show the importance of modeling the tax functions accurately in the lower regions of the income distribution. I perform the same experiment as in the first two rows of Table 4, except this time I use the smooth tax functions of Gouveia and Strauss (1994), shown in Figure 3. Using these tax functions, the model indicates that the changes in individual marginal tax rates had almost no effect on the long-run wealth distribution. There are several reasons to expect this tax function to be different from the statutory rates. The Gouveia-Strauss tax functions are *ex post* measures, whereas the statutory tax rates used to calculate the modified Altig-Carlstrom tax functions are obviously *ex ante* rates. Altig and Carlstrom use Adjusted Gross Income (AGI) to calculate their deductions functions. AGI excludes a substantial portion of realized capital gains, most Social Security benefits, and contributions to traditional IRAs, all of which are reported on tax returns. The income definition used to calculate the G-S effective tax functions includes all income that is reported on tax returns. Another possibly important difference be-

[17] As mentioned above, Díaz-Giménez, et al. (1997), using 1992 data, found that the correlation between wealth and income was 0.321. In my benchmark case with the 1989 modified Altig-Carlstrom tax functions, the correlation between income and wealth is 0.548. (The model's correlation between earnings and wealth is 0.331 versus 0.230 in the SCF data.)

tween the measures is that A-C's data only includes returns for married couples filing jointly, whereas G-S's data is not limited to this group. Given these differences in the definition of income and population, one would expect the G-S tax rates to be lower than the A-C rates. However, none of these differences account for the smoothness of the G-S rates compared to the stepwise statutory rates, nor do they seem likely to account for the fact that (after taking account of deductions), the statutory marginal rates were actually lower pre-reform than post-reform over certain ranges in the lower half of the income distribution. These ranges of income include a significant percentage of households (see Figures 1 and 2). As mentioned above, G-S's assumption of a smooth functional form for the tax function does not allow them to capture these changes in the marginal tax rates at low levels of income. This drives the differences in the model's predictions for the long-run wealth distribution.

Sensitivity Analysis

For sensitivity analysis, first I modify the government's problem so that all households receive the same lump-sum transfer. I set transfers equal to approximately 8.5% of GDP. This approximately matches the government transfers Medicare and Social Security as a percentage of GDP (Castañeda et al., (1998), p. 9). Each period the government collects tax revenues, gives some of it back to households as lump-sum transfers Z, and spends the rest on government consumption G which provides no utility to households. Table 6 reports the results of policy experiments using this modified version of the government's budget constraint. In these policy experiments I keep all other parameter values the same as in the benchmark cases.

Rows 1 of Table 6 shows the long-run wealth distribution under the 1984 modified Altig-Carlstrom tax functions. Under this tax and transfer system, wealth is much more equally distributed in 1984 than it is in the benchmark case reported in Row 1 of Table 4. When lump-sum transfers are equal across households, wealthy households pay a high level of taxes net of transfers in 1984. For example, post-fisc (i.e., pre-tax, pre-transfer) income is 40% lower for the highest-income household under this tax-and-transfer system than it is for a household with the same pre-fisc income in the benchmark case. Because their post-fisc income is lower now, high-income households cannot accumulate the large stocks of wealth that they accumulated in the benchmark case. On the other hand, low-income see an increase in post-fisc income relative to the benchmark case. For example, the median income household's post-fisc income is about 7.8% higher than a household with the same pre-fisc income in the benchmark economy. However, these low income households don't own much of total wealth. In equilibrium, the aggregate capital stock is lower than it was in the benchmark case, and thus the interest rate is higher. For the low-income households, the higher interest rate is enough to cause them to increase their savings. For example, in equilibrium, the wealth *level* of households at the 40th percentile increases relative to the benchmark case. The overall result is that wealth is much more equally distributed than in the 1984 benchmark case.

Row 2 of Table 6 shows the results of the redistributive tax-and-transfer system under the 1989 marginal tax structure. In this experiment, the *level* of transfers Z is the same as in Row 1. The economy grows about 1.8% in response to the tax reform (that is, relative to Row 1), and thus transfers as a percentage of GDP decrease slightly, from 8.6% to 8.4%. In 1989 under this tax-and-transfer system, wealth inequality is slightly *higher* that under the 1989 tax structure without redistribution (see Row 2 of Table 4). Again, low-income households have a higher post-fisc income than households with the same pre-fisc income under the 1989 tax structure without redistribution. But now the highest-income households receive only about 20 to 23% less than households with the same pre-fisc income under no government redistribution. In equilibrium, aggregate capital decreases and the interest rate rises relative to the "no-redistribution" case. However, this time the wealth and substitution effects play out differently. The effect of the higher interest rate is enough to outweigh the effect of lower post-fisc income for the *high* income households. The wealthiest households have higher *levels* of wealth as well as higher shares. For poor households, the effect of higher post-fisc income combined with the wealth and substitution effects of the higher interest rate depresses savings. In equilibrium, the poorest households decrease both their levels and shares of wealth relative to the 1989 economy with no direct government redistribution.

Even though marginal tax rates were lowered at most levels of income, tax revenue actually *increased* from 9.7% of GDP in 1984 to 11.3% in 1989. Qualitatively, the data tell the same story as my model[18]: according the BEA, tax revenue from the personal income tax increased from 7.7% of GDP in 1984 to 8.3% of GDP in 1989 (Slemrod and Bakija, 2000, p. 272). Rows 3 and 4 show the change in the wealth distribution using the Gouveia-Strauss effective tax functions. As we saw above, with the G-S tax functions, the tax structure barely changes, so the wealth distribution also hardly changes.

Suggestions for Further Research.

The Altig-Carlstrom tax functions do not capture several important aspects of the Tax Reform Act of 1986. Slemrod (1990) points out that changes in corporate

[18]However, the warning against comparing the long-run equilibria of the model to the data in 1984 and 1989 still applies.

taxes were an important feature of the reform, including a reduction in the basic tax rate, but an increase in the corporate tax base. Changes to capital gains taxation were also an important aspect of the tax reform. Since wealthier households tend to take more of their income in the form of capital gains and corporate dividends, (Kennickell and Woodburn 1997, Kennickell, et al. 2000), including these elements would tend to reduce the regressivity of the tax reform.

Appendix.

A.1 Calibration.

The calibration procedure is a modification of the one used by Domeij and Heathcote (2000). I have 3 discrete states of the productivity process, so I have a 3x3 transition probability matrix. To reduce the number of free parameters, I assume that the probability of transitioning from the highest state to the lowest state (and vice versa) is zero. Each row of the matrix must add up to 1, so I am left with 4 free parameters in the transition probability matrix. To help match the wealth distribution, I also choose a value for the borrowing constraint, $\underline{a}$. This gives me 5 free parameters to match the 5 statistics of the wealth distribution mentioned in the body of the paper. Assuming a normalized average productivity $\bar{\varepsilon}$, I have two more free parameters: two of the three productivity levels. I can choose these two free parameters to match my target statistics (ρ and σ) for the earnings process estimated by Storesletten et al. I use the procedure described in the appendix of Domeij and Heathcote (2000) to compute the standard deviation (σ) and autocorrelation (ρ) of my productivity process.

Other methods of matching the earnings process, such as the quadrature-based methods Tauchen and Hussey (1991) would allow me to obtain the best possible match of a continuous AR(1) earnings process conditional on the number of points in my grid. However, the quadrature-based method does not allow me to match the wealth distribution. The method I use enables me to match the wealth distribution while simultaneously matching the key features of the earnings process (variability and persistence).

A.2 Solution algorithm.

The solution algorithm is a modification of the one used in Huggett (1993). Define a grid over the asset space. We need enough gridpoints so that the highest asset value is above the endogenously determined $\overline{a}$. The grid should also be fine enough so that when computing the decision rule and distribution function, the approximation error is insignificant.

Step 1: Guess an initial decision rule $a_0(a, \varepsilon)$. Then solve the following problem using a modification of Coleman's (1990) "policy function iteration" method:

$$u'[a + \varepsilon wn - a_1(a, \varepsilon)q]q \geq \beta E \left\{ u'[a_1(a, \varepsilon) + \varepsilon' wn - a_0(a_1(a, \varepsilon), \varepsilon')q] \right\}, \qquad (9)$$

with equality if $a_1(a, \varepsilon) > \underline{a}$, for each a on the grid and for $\varepsilon \in E$, where taxes and transfers have been omitted for notational simplicity. After solving this problem for each gridpoint, repeat the exercise, replacing $a_0(a, \varepsilon)$ with $a_1(a, \varepsilon)$ and $a_1()$ with a $a_2()$. Iterate on this until the decision rule converges.

Step 2: Starting from any initial distribution over assets, iterate on the following until the distribution is approximately stationary:

$$F_{t+1}(a', \varepsilon') = \sum_{\varepsilon} \pi(\varepsilon' | \varepsilon) F_t(a^{-1}(a', \varepsilon), \varepsilon) \qquad (10)$$

for each gridpoint in S. The decision rule $a(a, \varepsilon)$ may not be invertible for some points, so define $a^{-1}(a', \varepsilon)$ as the highest a for which $a(a, \varepsilon) = a'$.

Step 3: Once the distribution function converges, calculate the aggregate capital stock. If we have $r = f_1(K, L) - \delta$ then we are done. Otherwise adjust q, recompute w and return to step 1.

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	Top 1%	Top 10%	Top 20%	60-80%	0-60%	Gini
1983	33.7	68.1	81.2	12.7	6.1	0.80
1989	38.9	72.3	84.5	11.5	4.0	0.84

Table 1: Percentage of total net worth held by U.S. households ranked by net worth (Wolff, 1994).

	Top 1%	Top 10%	Top 20%	60-80%	0-60%	Gini
1983	13.4	37.0	51.9	21.6	26.4	0.48
1989	16.4	40.1	55.5	20.7	23.9	0.52

Table 2: Percentage of total income held by U.S. households ranked by income. Source: Wolff's (1994) calculations from the 1983 and 1989 Survey of Consumer Finances.

Parameter	Value	Source	Chosen to match
$\pi(\varepsilon_l\|\varepsilon_l)$	0.98	Calibrated	earnings variability and persistence
$\pi(\varepsilon_l\|\varepsilon_m)$	0.049	" "	" "
$\pi(\varepsilon_m\|\varepsilon_m)$	0.95	" "	" "
$\pi(\varepsilon_h\|\varepsilon_h)$	0.90	" "	" "
ε_l	1.516	" "	" "
ε_m	2.85	" "	" "
ε_m	51.15	" "	" "
$\underline{a}$	-0.3	" "	" "
Model period	1 year	" "	" "
Tax Functions	see Figure 1	Altig et al. (1999)	marginal tax rates
β	0.96	standard	discount factor
μ	1.0	" "	Coeff. of rel. risk aversion
α	0.36	" "	capital's share
δ	0.1	RBC lit.	depreciation rate

Table 3: Parameter values and sources.

Row	Tax structure	GDP	Top 1	Top 10	Top 20	60-80%	0-60%	Gini
1	1984 A-C	0.990	37.2	65.8	77.7	14.9	7.3%	.790
2	1989 A-C	1.000	44.4	75.0	84.7	11.6	3.7%	.858
3	1983 G-S	0.995	44.1	76.3	85.9	11.2	2.9%	.870
4	1989 G-S	1.000	43.5	75.6	85.4	11.4	3.2%	.865
5	1983 (data)		33.7	68.1	81.2	12.7	6.1	.80
6	1989 (data)		38.9	72.3	84.5	11.5	4.0	.84

Table 4: Wealth distribution under different tax structures. (Data are from Wolff 1994.)

Year		Top 1	Top 10	Top 20	60-80%	0-60%	Gini
1989		29.5	64.0	79.3	16.6	4.2	0.791
1989 (data)		38.9	72.3	84.5	11.5	4.0	.84

Table 5: Wealth distribution in Castañeda et al.'s (1998) model.

Row	Tax structure	Z	G	GDP	Top 1	Top 10	Top 20	60-80%	0-60%	Gini
1	1984 A-C	8.6	1.2	1.000	27.2	54.4	68.1	18.4	13.5%	.687
2	1989 A-C	8.4	2.9	1.018	44.3	78.3	87.0	10.3	2.7%	.879
3	1984 G-S	9.0			35.0	69.0	79.7	13.3	7.0%	.804
4	1989 G-S	9.0			33.7	67.1	78.2	14.1	7.7%	.790

Table 6: Wealth distribution under different tax structures, with all housholds receiving identical lump-sum transfers. Transfers (Z) and Government spending (G) are as a percentage of GDP.

Row	Parameters	Earnings Gini	Wealth Gini	High a	GDP
1	μ=1.0	.210	.796	53.9	1.00
2	μ=2.0	.210	.686	51.9	1.07
3	μ=3.0	.210	.561	48.2	1.17
4	μ=1.0	.220	.705	47.5	1.015
5	μ=2.0	.220	.545	40.5	1.11

Table 7: Sensitivity analysis with no taxes. Rows 4 and 5 show results for a mean-preserving spread of the shocks.