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The Progressivity of Social Security*

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Abstract

How much does the current social security system redistribute from rich to poor? We propose alternative concepts of well-being that can be used to classify individuals from rich to poor, and we show how social security redistributes differently under each concept. We use the PSID to estimate lifetime wage profiles and actual earnings each year for a sample of 1778 individuals, and we use mortality probabilities to calculate expected payroll taxes and social security benefits. For a given set of "facts" about the net flows experienced each year by each individual, measured progressivity depends on many assumptions. This paper attempts to capture and to quantify all of the data and characteristics relevant to determine each individual's "income" under several definitions. We then use each definition of income to classify individuals from rich to poor and to calculate the progressivity of social security.

We proceed in seven steps. First, we classify individuals by annual income and use Gini coefficients to find that social security is highly progressive. Second, we reclassify individuals on the basis of lifetime income and find that social security is less progressive. Third, we remove the cap on measured earnings and find that social security is even less progressive. Fourth, we switch from actual to potential lifetime earnings (the present value of the wage rate times 4000 hours each year). This measure captures the value of leisure and home production, so those out of the labor force are less poor, and net payments to them are less progressive. Fifth, we assign to each married individual half of the couple's income. The low-wage spouse is then not so poor, and social security becomes even less progressive. Sixth, we incorporate mortality probabilities that differ by potential lifetime income. Since the rich live longer and collect benefits longer, social security is no longer progressive. Finally, we increase the discount rate from 2% to 4%, which puts relatively more weight on the earlier-but-regressive payroll tax and less weight on the later-but-progressive benefit schedule.

Depending on the definition of income used to classify people, the overall social security system could be deemed progressive, only mildly progressive, or neutral. With an even-higher discount rate, it could even be deemed regressive.

KEYWORDS: distributional effects, government pensions, lifetime incidence

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Social security payroll taxes constitute a full 33% of Federal revenues in the U.S., and social security benefits are 42% of all the income to the elderly. This massive redistribution program is generally thought to be an important progressive element of the social safety net. On an annual basis, it redistributes from high-income workers to lower-income retirees. Even on a lifetime basis, the benefit formula explicitly redistributes from those who earned more during their working years to those who earned less. Certainly Congress in the 1930s thought of social security as a way to take care of the poor elderly, and most studies that have evaluated redistribution in the system have found it to be progressive.

This paper revisits the issue of redistribution from social security. Our model has many features that are vital to assessing the progressivity of a life-cycle program. Some of these features are standard in the literature, while others are innovations. In measuring redistribution, we take a steady state approach in which all working and retirement years come under the current system. We thus focus on intra-generational redistribution and ignore effects between age cohorts. In this sense we assess the long-run redistributive effects of the current system. Then, for that long-run cohort, we consider alternative definitions of "income" that can be used to classify individuals from lowest to highest, and we measure the progressivity of the redistribution between those with different income.

While early legislators may have designed social security to redistribute toward elderly with low annual income, economists have pointed out that those recipients might not really be poor. With borrowing and lending, economic well-being might be better reflected by a measure of lifetime income. The power over economic resources might also be said to include the imputed value of time at home – time spent taking care of children, painting the house, or growing one's own vegetables. The value of those activities can only be imputed by attributing a wage to those hours, and so another measure of economic well-being is the "potential income" that could be earned with all those hours at the market wage. Moreover, a person's economic well-being may depend more on household income than on one's own earnings.

Thus we have several measures of "income", and the choice is somewhat subjective. We do not mean to imply that social security was intended to help those with less "potential lifetime income". Indeed, the original legislators probably had no such intent. Nonetheless, policymakers today might be interested in the extent to which social security does redistribute from those who are doing well to those who are not doing well, by a variety of measures such as potential lifetime income. Here, our aim is to look at reasonable alternatives and show how much difference it makes.

As explained more below, we focus on six choices about the definition and measurement of income: annual or lifetime; capped or uncapped; actual or potential; individual or household; using standard or income-differentiated mortality probabilities; and, using a low or high discount rate. These six choices yield $2^6 = 64$ possible measures of income, and each can be used to calculate progressivity. Instead of showing all 64 combinations, however, we start with a naïve definition and change one choice at a time in six additional steps to arrive at a more "sophisticated" definition that might appeal to economists. Each step reduces the measure of progressivity. In general, we conclude that the current social security system cannot be considered progressive.

First, however, we must construct a data set that can be used to measure each definition of income for a large sample of individuals. We use twenty-two years of data from the PSID for 1778 individuals to estimate the wage rate as a function of age and other characteristics, and we use the estimated coefficients to predict each individual's wage rate outside the 22-year observation period. We thus obtain the actual or predicted wage rate for each individual for 45 years (from age 22 to 66). To get a lifetime "endowment" of potential earnings for each individual, we take the present value of each year's wage rate times 4000 hours.

This "endowment" measure is then used to group similar individuals together. We allocate all individuals into five lifetime endowment quintiles, and for each quintile, we use the 22 years of PSID data again to estimate Tobit regressions of actual earnings on age and other characteristics. Then we use these estimated coefficients to predict each individual's actual earnings outside the 22-year observation period. We combine actual and simulated earnings information for each individual to construct a forty-five year earnings profile. Using actual earnings allows us to capture the effects of events that may lead individuals to enter and exit the labor force. Finally, for each person, we calculate social security tax in each working year and benefits in each retired year. We also incorporate information on spousal earnings and benefits that are important in determining the net benefits an individual obtains from the system.

We then use those actual and simulated observations as "facts" about the lifetime of each individual. For each definition of "income", we calculate each individual's income, classify them from rich to poor, and calculate how much the social security system takes from or gives to each income level. At each step, we measure redistribution in several ways. We look across individuals at social security net tax rates (tax paid minus benefit received, as a percent of income). We also plot before- and after-tax Lorenz curves, and we calculate before- and after-tax Gini coefficients.

In our first step we look at redistribution across individuals classified by their own annual social security wages, that is, redistribution from working individuals to retirees. As expected, we find social security to be highly progressive. In our second step, like other prior research, we classify individuals by lifetime earnings (still capped at the social security taxable maximum). The effect of social security is much less progressive on a lifetime basis, because

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retirees with zero labor earnings are now classified according to their total lifetime resources. In our third step, we remove the cap on measured earnings (to see the effect of changing from the use of capped data as in earlier studies to the use of uncapped data available from the PSID). This change further dampens the measured progressivity of the overall system, because wages above the cap are not subject to payroll tax. In the fourth step, we re-classify individuals according to "potential lifetime income." Here we assign a wage rate to each person in each period and multiply it by a total endowment of hours, to get a measure of well-being that includes leisure and home production rather than just market labor supply. Thus a high-wage person who chooses to work part-time or to spend several years out of the labor force is no longer classified as low-income. This re-classification also weakens the measured progressivity of the system.

In step five, we pool the resources of husbands and wives so that each individual is classified according to per capita lifetime household income. As we are now putting low- and high-earning spouses in the same income group, the progressivity of social security continues to erode. In step six, we account for mortality probabilities that vary by lifetime income. Since high income people tend to live longer, and get more benefits, we then find that social security can scarcely be considered progressive. Finally, in step seven, we move from a 2% to a 4% percent discount rate. With more weight on the earlier years' regressive payroll tax and less weight on the later years' progressive benefits schedule, the whole system becomes less progressive or approximately neutral. With an even higher discount rate, social security could be deemed regressive.

This study focuses on the retirement portion of social security, ignoring disability and hospital insurance. By tracking dollar flows, we also ignore the utility value of reducing income risk. By taxing earnings and paying benefits during retirement, social security reduces the variance of income within each person's lifetime. We cannot ascertain the *value* of this risk reduction, but we can shed light on the *amount* of such risk reduction at each income level. We find that social security reduces the standard deviation of income more at high income levels, but it reduces the coefficient of variation more at low income levels.

Milton Friedman (1972) and Henry Aaron (1982) have hypothesized that some of these implicit features of social security may reduce the explicit progressivity of the benefit schedule. As reviewed below, at each step, other papers have measured the effect on progressivity from some of these implicit features. The point of this paper is to add a few steps and to calculate the effect of each such step within the context of a single comprehensive model.

I. Lifetime Earnings Profiles and Net Benefits from Social Security

In this section we describe the data and methodology used to obtain lifetime earnings profiles, to estimate mortality probabilities that differ by lifetime income, and to calculate net benefits from social security. A more detailed description is provided in a technical appendix. We use the PSID for the years 1968 to 1989, which gives us twenty-two years of actual earnings data for our sample.

We select our sample based on three criteria. First, our sample members are not taken from the low-income subsample of the PSID. While the data contain weights for the low-income sample to be merged with the representative sample, we felt that the representative sample provided sufficient data for our purposes. Second, to get an adequate number of observations for each person, we kept only those who remain in the sample for the entire period. Survey respondents may have died, or simply decided that the survey was no longer worth their time. Including those who dropped out of the sample was judged not to be worth the possible distortion in the data and additional computational work required to track these individuals. Third, in order to avoid problems with divorce and other family changes, we only include individuals whose relationship to head status did not change during the sample period.[1]

Because of these criteria, we cut off a group of individuals who were less than 30 in 1968. We disproportionately eliminate women, because the PSID always classifies the man of a couple as the head of household. A single man who marries during the period remains head of household and is included in our sample, but a single woman who marries does not maintain the same relationship to head status for the whole period and would be excluded.

Our final sample consists of 1086 heads and 700 wives. It captures 66 percent of the original, non-low-income PSID sample, including 92 percent of heads and 62 percent of wives. Because we did not extract data for those who dropped out of the sample and those who changed their relationship to head, we cannot formally test whether this exclusion biases the parameters in our wage and earnings regressions. As reflected in appendix Table A1, however, the observable characteristics of our sample are remarkably similar to the original sample. We therefore believe it is unlikely that our econometric estimates are significantly biased, or that our sample selection skews the conclusions we draw about the progressivity of social security. We recognize that this sample does not exactly represent all recent and future Americans, especially after immigration and other demographic changes, but we think that these calculations still provide interesting insights about how social security affects a major subset of Americans.

[1] The PSID sample was originally chosen to be representative in 1968, and our data derive from observations through 1989. Nonetheless, we assume that these observations represent a long-run future cohort under current law – as if neither demographics nor behavior were to change.

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Our PSID sample contains only twenty-two years of actual data. In order to obtain complete profiles from age 22 through retirement for each of our sample members, we want to generate out-of-sample wage and earning observations. To do this, we first estimate wage rate regressions and use the estimated coefficients to predict a wage rate for the rest of each person's working life. However, as Fullerton and Rogers (1993) demonstrate using data from the PSID, lifetime profiles can have significantly different shapes for different lifetime income groups. We therefore place individuals into quintiles defined by the present value of their endowment, and then estimate separate Tobit regressions on actual earnings. We use the estimated coefficients from these Tobits to simulate each individual's actual earnings outside the 22-year window.

Our model is somewhat stylized in that our measures of income all ignore inheritances and transfers. Annual income includes only wages, which are zero for a retired person. Lifetime income is the present value of that annual income. Capital income from lifecycle savings is *not* part of lifetime income: if the present value of consumption must equal the present value of labor income, then capital income just reflects rearrangements in the timing of consumption.

To each lifetime profile, we add mortality probabilities that vary by our measure of potential lifetime income as well as by age, gender, and race. We calculate expected social security taxes paid for each person for each year during their working life and expected benefits received during retirement, following current provisions of the Social Security Administration (SSA). Those provisions specify that age 67 will be the normal retirement age,[2] and we assume that all individuals retire at the normal retirement age.[3] Finally, then, we combine these calculated taxes and benefits to compute each person's expected net benefit.

a. The Value of Lifetime Endowment

To begin, we calculate an annual wage rate for each member of our sample by dividing annual earnings by hours worked. To construct a wage rate for every year of each sample member's working life, we first use all positive wage observations to estimate log wage profiles. We estimate three separate log wage

[2] Legislation already enacted increases the retirement age by two months each year beginning in 2000, so that by 2005 the normal retirement age is 66. Another two month per year increase will begin 2017, resulting in a normal retirement age of 67 after the year 2021. We consider a hypothetical future year under current law, with the normal retirement age of 67.

[3] While a majority of retirees claim early retirement, they get a reduction in benefit that is supposed to be actuarially fair. Different retirement ages only affect our measure of progressivity if the change in benefits is not actuarially fair *and* the chosen retirement age varies systematically across income levels. Coile *et al* (2002) find a U-shaped pattern: at low wealth, more wealth reduces early retirement, while at high wealth, more wealth increases it.

regressions: for heads, for full-time or frequently working wives, and for part-time or occasionally working wives. The results of these regressions can be found in the appendix. We regress the log of the wage rate on an individual fixed effect and other variables like age, age-squared, and age-cubed. Because we have a fixed effect for each individual, we cannot use variables that do not vary over time (like race or gender). However, we do include age *interacted* with education, race, and gender. Using the resulting fixed effects and coefficients, we then fill in missing observations during the sample period and observations outside the sample period. The appendix details how we assign a wage rate to women who have no earnings histories (despite the selection problems in doing so). Non-working wives do engage in household production, and assigning them a zero wage may understate their lifetime endowment, used to classify them for earnings regressions and for the distributional analysis. Thus, for each individual, we have a wage rate for every year of their economic life from age 22 to 66.

We then use this wage rate and multiply it in each year by 4000 hours to represent the year's labor endowment. This product represents the potential earnings of the individual and therefore serves as a reasonable measure of his or her material well-being. Using this endowment allows us to abstract from the actual labor/leisure choice, since someone who chooses to work less and consume more leisure might be just as well off as someone who decides to work more and consume less leisure. Using potential income also avoids the distortion introduced by the fact that home production does not show up in the data under hours worked. The wage rate is a measure of earning power that reflects experience, talent, and education. We recognize that we cannot really measure true potential for earning income, which may depend on individual disabilities or market limitations we cannot observe. Rather, we use an imperfect estimate of potential income, to see what results suggest about how social security may redistribute among those with different abilities.

Once we have a complete wage profile for each of our heads and wives for ages 22-66, we calculate individual gross lifetime income as:

$$LI = \sum_{t=1}^{45} [(w_t \times 4000)/(1+r)^{t-1}] \tag{1}$$

where t indexes the forty-five years in the individual's economic lifetime relevant for social security, ages 22 to 66, and where the individual could work a maximum of 80 hours per week for 50 weeks per year. Through most of our analysis, we use a value of 2% for r, the real discount rate.[4] Later, we see the effect of raising the discount rate to 4%.

[4] The 2% rate lies between the 1.4% average for real government bond returns reported by

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As couples generally pool their resources, it may be inappropriate to say that husbands and wives have different levels of "material well-being". The low-wage wife of a high-wage husband is not "poor". We therefore combine the lifetime endowment of the husband and wife, and divide by two, to obtain a reasonable measure of each individual's lifetime material well-being. We can now deal with each member of our sample as an individual and categorize them into quintiles defined by lifetime endowment.

b. Earnings Profiles

Once we have people classified into lifetime endowment groups based on a measure of economic well-being, we estimate regressions for actual earnings. Using our data from the PSID, the appendix describes how we estimate fifteen separate regressions – for each quintile's actual earnings of heads, frequently working wives, and occasionally working wives. We use both positive and zero earnings observations in a Tobit framework.

Because the Tobit framework is nonlinear, we do not include fixed effects as their inclusion would imply inconsistent parameter estimates. The exclusion of fixed effects also means we can use variables in these earnings regressions that do not vary over time, such as education, race, and gender. For each regression for the heads, we begin with independent variables for age, age-squared, age-cubed, education, education-squared, the product of age and education, a dummy for whether the head is female, age interacted with the female dummy, and a dummy for whether the head is white. We then eliminate the variables that were insignificant. We follow a similar procedure for habitually or frequently working wives, and for the part-time or occasionally working wives.

We next use the estimated coefficients from our earnings regressions to simulate earnings observations for the out-of-sample years for all individuals in our sample. We do not use these coefficients to fill in missing earnings observations during the sample period, as we are interested in actual earnings, and years spent out of the labor force are relevant for calculating the costs and benefits of social security. In fact, we also simulate a representative number of zero earnings years for the out-of-sample portions of each earnings profile.

Combining the actual observations with simulated observations for each individual yields a complete earnings profile for ages 22 to 66. One advantage of using these profiles is that we can account for entry and exit from the labor force. These events are relevant when evaluating the redistributive impact of social

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Ibbotson Associates (1998) and the 2.8 % forecast rate for the OASI trust fund. In other studies of social security, Myers and Schobel (1983) use 2%, Hurd and Shoven (1985) use 3%, Boskin, *et al* (1987) use 3%, Duggan, *et al* (1993) use 1.2%, Steuerle and Bakija (1994) use 2%, and Gramlich (1996) uses 2.3%. In contrast, Caldwell *et al* (1999) use 3%, 5%, or 7%.

security, because benefits are based on earnings histories and allow for a certain number of years to be dropped before making average wage calculations. Another advantage is that we have a demographically diverse sample. This diversity affects our analysis in that different demographic groups have different numbers of single and married households, different earnings patterns, and different mortality rates. These differences turn out to be an important issue in analyzing social security, as described below.[5]

c. Income-differentiated Mortality

As a stylized fact, people with higher incomes tend to live longer, which can dampen the progressivity of the benefit structure of the social security system. However, standard mortality tables extend only to age 85 and are differentiated only by sex and race. We extend these data in three ways. First, we extend the tables to age 99. Second, we modify the standard tables by using available information on mortality differentiated by *annual* income. Third, we then use that information to construct mortality tables that are differentiated by *lifetime* income. In later sections we use these tables to compute expected present values of social security taxes and benefits.

Standard mortality tables are provided in *Vital Statistics of the United States* (U.S. Department of Health and Human Services, 1993). They obtain death certificates from all U.S. states and construct four "current life tables" (for white males, white females, nonwhite males, and nonwhite females). For 100,000 individuals alive at age 0, the table shows the number surviving at each age 1 through 85. Since 31% of the population is still alive at age 85, the appendix describes how we extend the tables through age 99. These expanded mortality tables allow us to weight tax payments and benefits by the probability of being alive in each year.[6]

Many studies have noted that mortality rates for the poor are larger than average. *A Mortality Study of 1.3 Million Person* (Rogot, *et al*, 1992) provides a

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[5] We start with age 22 because earnings information before that age is unreliable. Yet those who work earlier than age 22 pay social security tax without increasing retirement benefits, because the program only counts the highest 35 years of earnings. If those individuals are predominantly in low lifetime income groups, then our overall measure of progressivity may be overstated at all steps, but it is not clear how the comparative results of each step would be affected.

[6] Some prior studies use a simple procedure in which they compute normal life expectancy at each age and then assume that the individual will be alive exactly that long and will die at the date of life expectancy. Instead, we use the probability of remaining alive at each age. Based on standard mortality tables, a hypothetical 22 year-old white male has probabilities of survival to age 23 of 99.83%, survival to age 65 of 75.82%, and survival to age 85 of 22.34%. We multiply the tax that would be due or the benefit that would be received at each age by the probability of attaining that age, and then calculate the present value of these expected cash flows.

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rich source of data on this effect. They show the observed number of deaths for each annual income class of each race, gender, and ten-year age group. For each such cell, we divide observed deaths, *O*, by the expected deaths, *E*, that would occur if all income classes of that group had the same mortality rate. We then apply that *O*/*E* ratio to each cell in the extended mortality tables. Among white males aged 25-34, for example, those in the poorest annual income group die at a rate that is 168% of the average, while those in the richest annual income group die at rate that is only 61% of the average. For nonwhite females of the same age, the poor die at a rate that is 186% of the average, while the rich die at a rate equal to 44% of the average.

Although we have the annual household income of each individual in our sample for each year, we do not just use the corresponding annual income group's *O*/*E* ratio for that person in that year to weight their mortality probability. Using annual income would imply that an individual with a steeply hump-shaped earnings profile would have a probability of dying that falls dramatically during high-annual-income years and then rises again during low-annual-income years. Instead, the probability of dying is more likely affected by the individual's *lifetime* income. To address this issue, our procedure described in the appendix is based on the relative ranking of each individual's lifetime income. Basically, a person in a particular percentile of the lifetime income distribution is assigned the *O*/*E* ratio of a person in the same percentile of the annual income distribution.[7]

A remaining problem, however, is related to causality: our procedure essentially uses the individual's income as a determinant of death, even though annual income may be determined in part by illness immediately preceding death. This problem is somewhat mitigated by the fact that the CPS data used by Rogot *et al* (1992) is based on total combined family income, rather than just the decedent's own income. In any case, as shown by others, our use of income-differentiated mortality has only small impact on the measure of progressivity.[8]

d. Social Security Taxes Paid

We next compute social security tax for each person in each year, following the SSA. This tax is called the FICA tax (Federal Insurance Contributions Act). It is collected on earned income and consists of three portions: Old Age and Survivors

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[7] Thus, even if two retirees have the same low annual income, the one with higher lifetime income is assumed to have a lower mortality probability.

[8] Other studies use education as an exogenous proxy for lifetime income to calculate effects of differential mortality on progressivity of social security, and they also find effects to be small (Liebman, 2002; Harris and Sabelhaus, 2005; and Brown *et al*, 2009). As shown in Brown *et al* (2009), the size of this effect depends slightly on the order of the steps (for example, whether income groups are differentiated by actual lifetime earnings or by potential lifetime earnings).

Insurance (OASI), Disability Insurance (DI), and Hospitalization Insurance (HI), also known as Medicare. The proceeds from these taxes are deposited into three separate trust funds, and benefits are paid from the appropriate fund. The program is almost universal -- 95% of all employment in the U.S. is covered.[9]

The tax is deducted from employees' pay at a rate of 7.65% of wages, but employers match that tax for a total of 15.3%. Self-employed individuals pay the entire 15.3% tax annually with their income tax returns. Both the employee and employer shares are collected on wages up to a maximum amount of taxable earnings -- the social security wage cap ($68,400 for 1998). This cap is adjusted automatically each year with the average earnings level of individuals covered by the system, thereby accounting for both real wage growth and inflation.

Since we seek to measure each worker's net social security tax burden, the question arises: how much of the total FICA tax does the worker bear? Using only the statutory incidence (the worker's half) would yield much lower burdens than the combined employer and employee portions. Hamermesh and Rees (1993, p.212) review empirical work on payroll tax incidence and conclude that the worker bears most of the employer's tax through reduced wages. We therefore base our estimates on the combined employer and employee tax.[10]

Our focus is the retirement portion of the social security system, not disability insurance or hospital insurance. Of the total 15.3% tax, 10.6% is for Old Age and Survivors Insurance (OASI), 1.8% is for Disability Insurance (DI), and 2.9% is for Medicare (HI). The OASI portion of the tax is used to pay all retirement benefits. We therefore ignore the DI and HI portions of the tax, as well as benefits paid from the DI and HI Trust Funds.

Our sample from the PSID includes observed and constructed earnings for each individual from age 22 to the age of retirement. To obtain steady-state taxes and benefits under current law, we look at a hypothetical future cohort with a birth year of 1990. We therefore take N_{oij}, the "observed" nominal earnings of individual i in year j, and we convert it to the corresponding future individual's

[9] Coverage may be excluded for: federal civilian workers hired before 1984 who have not elected to be covered; railroad workers who are covered under a similar but separate program; certain employees of state and local government, covered by their state's retirement programs; household workers and farm workers with certain low annual incomes; persons with income from self employment of less than $400 annually; and those who work in the underground, cash, or barter economy who may illegally escape the tax.

[10] Panis and Lillard (1996) point out that because the employer's portion of the payroll tax is deductible against the income tax, the net cost of the tax is lower than the full amount of the payroll tax paid. Like Panis and Lillard, and for comparability with other studies, we treat the entire amount of the payroll tax as the employee's cost of social security coverage. In effect, we look at the social security system only, without any income tax. The combined incidence is not equal to the sum of the parts, but we cannot say whether the income tax affects the incidence of social security, or social security affects the incidence of the income tax.

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nominal earnings, N_{fij}, using the ratio of projected average earnings in the future year (AE_{fj}) to observed average earnings in the PSID sample year (AE_{oj}):

$$N_{fij}=N_{oij}(AE_{fj}/AE_{oj}) \quad . \tag{2}$$

Since 1951, the SSA has computed Average Earnings, the average annual earnings of all workers covered under the Act. We project this Average Earnings into the future using assumptions about future real wage growth and inflation.[11]

In our study, we calculate the present value at age 22 of mortality-adjusted social security taxes and benefits through age 99. The probability P_{ij} of individual i being alive at age j is conditional on being alive at age 22, and it is computed from the constructed tables (for each age-race-sex-income cell) as the number in cell i alive at age j divided by the number in cell i alive at age 22. We then calculate $E(SST_{ij})$, the expected social security tax of person i in year j:

$$E(SST_{ij}) = [T \times \mathrm{Min}(N_{ij}, CAP_j)] \times P_{ij} \tag{3}$$

where T is the combined OASI tax rate (which is constant with unchanged law), CAP_j is the maximum nominal earnings subject to the OASI tax (which increases with inflation), and P_{ij} is the probability that person i is alive at age j. These amounts are used to compute the present value of social security taxes paid.

e. Social Security Benefits

Under provisions of the Social Security Act, benefits are calculated from a progressive formula based on the individual's Average Indexed Monthly Earnings (*AIME*). Our calculations follow the SSA computation of *AIME* upon retirement. In particular, earnings prior to age 60 are indexed to average wages in the year the individual attains age 60. Only earnings at or below the taxable cap in each year are considered. The method of indexing is to multiply the nominal earnings in year j by the ratio of Average Earnings in the year age 60 was attained to Average Earnings in year j. Earnings after age 60 are not indexed. A person who works from age 22 through age 66 would have a total of 45 years of earnings. Under the Act, only the highest 35 years are considered, so the ten lowest years will be dropped. *AIME* is the simple average of the indexed earnings in those 35 highest-earnings years.[12]

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[11] We use actual inflation and growth to scale observed PSID years up to 1995. Since amounts in future years are indexed, the subsequent inflation and growth rates are set to zero.

[12] The language of the Act specifies dropping the *five* lowest years of earnings through age 61. Then, if the worker has years of earnings after age 61 that are higher than some earlier years' earnings, the higher post-61 earnings will replace those lower earnings. The net effect for a

Next, the Primary Insurance Amount (*PIA*) is calculated as 90% of *AIME* up to the first bend point, plus 32% of *AIME* in excess of the first bend point but less than the second bend point, plus 15% of *AIME* in excess of that second bend point. The fact that only capped earnings are used to calculate *AIME* provides a *de facto* maximum benefit. In 1995, the bend points were \$426 and \$2,567. If *AIME* were \$3,200, for example, the *PIA* would be:

$$PIA = .90\times(426) + .32\times(2{,}567 - 426) + .15\times(3{,}200\text{-}2{,}567) = \$1{,}163.47 \qquad (4)$$

Like the cap on earnings, the bend points are adjusted annually by the proportional increase in Average Earnings. We calculate this *PIA* for each worker in the sample, which then becomes the basis for all benefit calculations.

A retiree is entitled to a benefit equal to the *PIA* upon normal retirement at age 67. A worker may still choose to retire as early as age 62, with reduced benefits.[13] In contrast, if a worker elects to *delay* receipt of benefits up to age 70, the eventual benefits are permanently increased by 5% per year of delay. Our calculations below ignore these provisions for early or late retirement, as we assume workers (and their spouses) always choose the normal retirement age.

In addition to retirement benefits for covered workers, the OASI Trust Fund provides certain benefits to the spouse and other dependents of retired or deceased workers. The spouse of a retired worker can receive the greater of the benefit based on his or her own earnings, or one-half of the *PIA* of the retired worker (designated as the "spousal benefit"). Then, once spousal benefits have begun, cost-of-living adjustments for the spousal benefit are handled in the same manner as for the worker's benefit. The spouse of a *deceased* worker can receive the higher of the benefit based on his or her own earnings, or 100% of the benefit to which that worker was entitled. The benefit based on the deceased worker's benefit is called the "survivor benefit". We ignore non-spousal survivor benefits; in aggregate they are relatively minor.[14]

Our calculations of these amounts are detailed in the appendix. We use each individual's observed and constructed earnings to compute Average Indexed Monthly Earnings (*AIME*), the Primary Insurance Amount (*PIA*), the Spousal

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worker retiring at age 67 is to drop the ten lowest years.

[13] This early retirement penalty is a permanent reduction in the *PIA* of 5/9% for each early month (6.67% for each early year). For example, a worker retiring at age 64 when the normal retirement age is 67 would receive a benefit for the rest of his or her life that is reduced by 20%.

[14] In 1996, a total of \$302.9 billion were paid from the OASI trust fund. Of that total, \$288.1 billion went to retired workers or their spouses, and only \$14.8 billion (4.9%) went to other survivor and miscellaneous benefits (*Annual Statistical Supplement, 1997,* Table 4A.5).

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Benefit (SpBen), and the Survivor Benefit for the surviving spouse (SurvBen) in exact accordance with provisions of the Act.

II. Redistribution under the Current Social Security System

In this section we use our lifetime income profiles and expected net benefits from social security to examine how social security redistributes income from rich to poor. We examine the degree of progressivity of net benefits under varying assumptions about income measures, mortality rates, and discount rates. We change these assumptions in seven steps, so that each step shows the effect of a particular assumption. Across all of these calculations, our sample individuals are assumed to have the same fixed behaviors and outcomes in each year, regarding wage earnings, social security taxes paid, and social security benefits received. The point of the paper involves *how* those outcomes are characterized.[15]

At each step, we examine several measures of redistribution. The first measure is based on each person's net social security tax rate: the present value of expected tax minus expected benefits as a percent of the individual's income. In a scatter diagram, we show all 1,778 tax rates plotted against the income measure. If the system is progressive for that definition of income, that scatter diagram will show a positive relationship with higher tax rates for those with higher incomes.[16]

We also measure progressivity using the Lorenz curve. At each step, we order all individuals by the relevant measure of income (from low to high). The Lorenz Curve then plots the cumulative percentage of total income on the y-axis against the cumulative percentage of total population on the x-axis. Both the x and y axes range from zero to one, and a 45° line from the origin (0,0) to (1,1) represents the case with equal incomes. At each step, for each definition of income, we show the degree of inequality before social security, with the Lorenz Curve below the 45° line, and we show how much the social security system shifts the post-tax curve toward the 45° line.

Next, we calculate the Gini index, the area between the equal-income line and the Lorenz curve divided by the whole area of the triangle below the equal-income line. The appendix describes this calculation. A Gini value closer to zero

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[15] Behavioral reactions can be calculated in a general equilibrium model for a limited number of consumer types (such as the 12 lifetime income groups in Fullerton and Rogers, 1993, and Kotlikoff, *et al*, 2002). Our goal here, however, is to capture the effects of diversity within each income group. Coronado, *et al* (1999) use this model to evaluate particular reforms.

[16] Many papers calculate the internal rate of return and find that social security offers different rates of return to individuals at different levels of income. While it may be useful for some purposes, this measure does not indicate the dollar gains or losses, and it does not indicate progressivity. Standard textbooks define a system to be progressive if the tax as a fraction of income rises with income.

indicates a more-equal distribution of income, while a value closer to one indicates more concentrated distribution.

At each step, we calculate the Gini index before and after the social security system's taxes and benefits. Finally, to summarize the redistributive effect of social security, we use the "effective progression" (*EP*) measure of Musgrave and Thin (1948), also described in Kiefer (1984):

$$EP = \frac{1 - Gini_{AT}}{1 - Gini_{BT}} \tag{5}$$

where $Gini_{BT}$ and $Gini_{AT}$ are the before-tax and after-tax Gini indices, respectively. A value of one for EP indicates that the before- and after-tax Gini indices are the same, and thus that social security has no impact on the distribution of income. A value above one indicates a progressive system, and a value less than one indicates regressivity.[17]

Some prior studies have examined redistribution from social security on an annual or lifetime basis using three hypothetical groups rather than actual data. Panis and Lillard (1996) set the "low" group at the full-time minimum wage rate, the "middle" group at the Social Security Average Earnings, and the "high" group at the wage cap. In that case, no group has earnings *above* the wage cap. Other studies use actual data from social security records, but those records also exclude any earnings above the cap.[18] Yet wages above the cap are needed to be able to capture the regressive nature of payroll taxes that apply only up to the cap. In contrast, as described in the previous section, our study uses data from the PSID for actual earnings that are not top-coded. To see how much difference it makes, however, we first *reduce* annual earnings to the cap whenever a person's actual

[17] Keifer (1984) also reviews other indices of progressivity. Some of these use the same information as the EP measure. For example, the Pechman-Okner (1974) index is calculated as $[(Gini_{AT} - Gini_{BT})/Gini_{BT}]$. Other measures such as the Suits (1977) index are based on the tax concentration curve. It is calculated like the Gini coefficient but with the cumulative tax liability on the vertical axis plotted against cumulative income on the horizontal axis. This index is useful to analyze the incidence of pure taxes, but it cannot be used for our net social security tax rates. Since the net tax is negative for some individuals, the curve would not lie within the 1×1 box.

[18] Three or more hypothetical or arbitrary income groups are used by Myers and Schobel (1983), Hurd and Shoven (1985), Boskin, *et al* (1987), Steuerle and Bakija (1994), Garrett (1995), and Diamond and Gruber (1999). Actual social security records are used by Burkhauser and Warlick (1981), Hurd and Shoven (1985), Duggan, *et al* (1993, 1995), Liebman (2002), and Gustman and Steinmeier (2001). To estimate uncapped earnings from social security records, Fox (1982) uses information on the time of year an individual reaches the maximum. Liebman (2002) performs other imputations to assign earnings to each top-coded individual. Caldwell, *et al* (1999) use simulated data on earnings that are not top-coded.

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annual earnings exceed the cap. We then modify that capped annual income concept as we proceed through our seven steps.

Step One: Redistribution by Annual Capped Wage Income

We begin with annual redistribution because that was a primary concern of the creators of social security. "Early twentieth-century writers on the old argued that technological change in manufacturing was forcing older men out of the labor force" (Costa, 1998, p. 21-2). Because most workers did not earn enough to save for retirement, and because industrialization had broken down the traditional extended family, the elderly had nothing to fall back on. As pointed out by Steuerle and Bakija (1994, p. 14), "The Committee on Economic Security of 1935 made clear these needs-based progressivity goals by stressing that poverty among the elderly was the primary problem to be addressed." Indeed, many recent papers continue to focus on the way social security affects the annual incomes of poor elderly individuals.[19]

Some earlier studies used social security data, with wages truncated at the cap, but our PSID data on wages are not capped. To see how much difference it makes, we start with capped wages and later generalize to uncapped wages.

Our first step is a calculation representing the entire U.S. population alive during a single year, using that year's capped earnings as the measure of income.[20] The net social security tax is positive for workers with positive income, and it is negative as benefits are paid to retirees with no income. Thus, *ex ante*, we expect to find that social security is highly progressive.

In order to estimate the redistributive effect of social security based on annual income, we pool all data. Each of our 1,778 individuals has 78 "observations" from age 22 through 99, so we have a total of 138,684 points. Because our system is in steady state, and we have removed the effects of growth and inflation, we can think of these observations as if they occur in a single year. We must weight each observation by the probability of survival to that age, however, to make the sample representative of those alive in a single year, for a steady state population.

The before- and after-tax Lorenz curves are shown in Figure 1. Because of the number of retirees with no income before social security, the before-tax curve is extremely bowed. The after-tax curve lies well inside the before-tax

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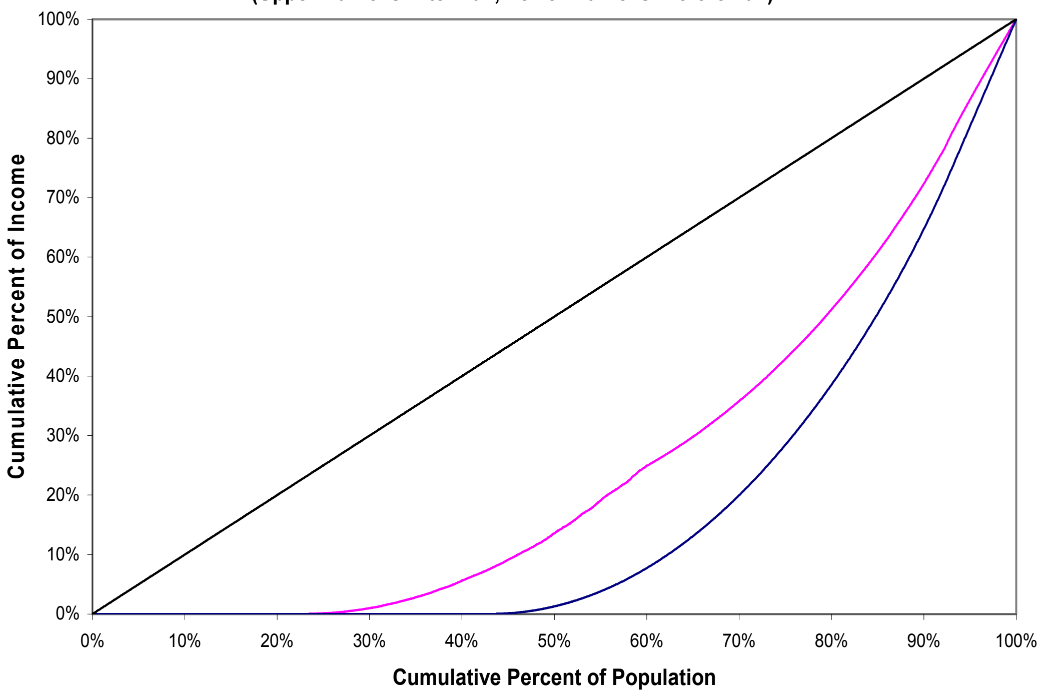
[19] Annual income is used in recent U.S. papers such as Johnson (1999) and McGarry (2002). Annual and lifetime measures are compared for the Netherlands by Nelissen (1998).

[20] The typical measure of annual income would include labor earnings, transfers, and capital income. Our data provide no good measure of capital income, however. Our goal is not to re-create a perfect measure of a flawed concept (annual income), but simply to demonstrate the large differences in measured progressivity that arise when using annual versus lifetime income.

curve, indicating that social security is strongly progressive. The Gini indices and the Musgrave-Thin measure of effective progression (*EP*) are shown in the first row of Table 1. As expected, the Gini coefficient is reduced by social security, from 0.64 to 0.55, indicating a reduction in the concentration of income. The *EP* measure is 1.27, indicating a strongly progressive impact from social security.[21]

Figure 1
Lorenz Curves for Annual Capped Earnings, with Standard Mortality
(Upper Curve is After Tax, Lower Curve is Before Tax)



Step Two: Redistribution by Lifetime Capped Wage Income

While a social insurance program for destitute elderly may have been the original goal of social security, the structure of the program is like a retirement saving program. Workers make "contributions," and retirees receive benefits, so many think of social security in the context of a life-cycle model. We now move from

[21] These figures can be compared to others using annual income in the U.S. to measure the effects of *all* taxes and transfers. The OECD (1995) reports a smaller Gini of 0.34, after taxes and transfers, but their income measure is top-coded. Using a broader measure of annual income, Lerman and Yitzhaki (1995) calculate a Gini coefficient of 0.67 before taxes and transfers, and 0.58 afterwards. The corresponding *EP* measure is 1.16. Looking only at individual income taxes, Keifer (1984) finds that the Gini falls from about 0.47 to 0.44 (*EP*=1.06).

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annual to lifetime measures of income to classify individuals and to measure redistribution. We take into account expected taxes paid and benefits received over a lifetime. In this context, social security will be progressive if the present value of expected *net* taxes are a higher proportion of lifetime income for those with higher income.

Table 1: Summary of Progressivity Measures for Social Security

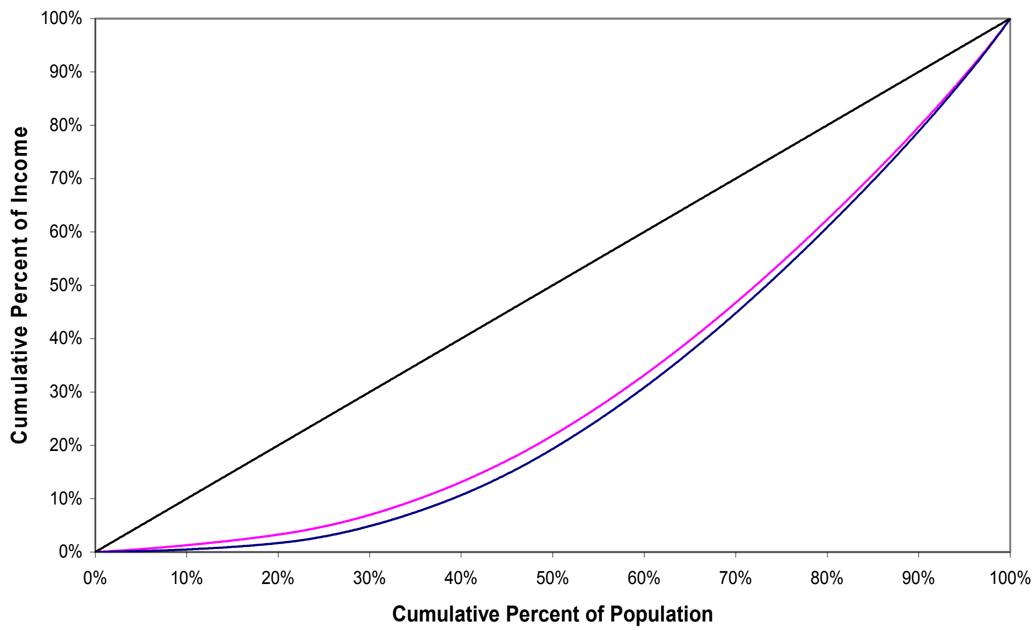
	(1) Income Measure	(2) Type of Mortality	(3) Discount Rate	(4) Gini Index Before-Tax	(5) Gini Index After-Tax	(6) Effective Progression	(7) Overall
Case 1	Annual Capped Earnings	Standard	NA	0.6427	0.5450	1.2734	*Progressive*
Case 2	Lifetime Capped Earnings	Standard	2%	0.3987	0.3664	1.0537	*Less Progressive*
Case 3	Lifetime Uncapped Earnings	Standard	2%	0.4357	0.4076	1.0498	*Less Progressive*
Case 4	Individual Potential Income	Standard	2%	0.2664	0.2591	1.0100	*Less Progressive*
Case 5	Household Potential Income	Standard	2%	0.2142	0.2123	1.0024	*Less Progressive*
Case 6	Household Potential Income	Income-Differentiated	2%	0.2198	0.2192	1.0008	*Less Progressive*
Case 7	Household Potential Income	Income-Differentiated	4%	0.2181	0.2199	0.9977	*Regressive*

Note: The Gini index is zero in the case of perfect income equality, and 1.0 with perfect inequality. The Gini Index before-tax in column (4) and the Gini Index after-tax in column (5) are used to calculate the "Effective Progression" measure of Thin and Musgrave (1948) in column (6), using equation (5) from the text. If the tax system does not change the Gini Index, this measure is 1.0, and the tax is "proportional." A tax system that lowers the Gini (toward equality) has *EP*>1 (is "progressive"), and one that raises the Gini Index has *EP*<1 ("regressive").

We therefore calculate "lifetime capped earnings" for each person as the present value of annual incomes from the previous step, using a 2% discount rate. Survival probabilities from *Vital Statistics of the United States-1989* are extended and used to weight taxes, benefits and income.

Figure 2a plots the resulting Lorenz curves before and after social security. Using lifetime earnings makes the distribution of income more equal than using annual earnings, since the before-tax curve is not as bowed as in Figure 1. The after-tax curve in Figure 2a still lies everywhere inside the before-tax curve, indicating that social security makes the distribution of lifetime income more equal. The difference between the before- and after-tax curves is much smaller than it was in Figure 1, indicating that social security is less progressive when income is measured on a lifetime basis.

Figure 2a
Lorenz Curves for Capped Earnings, with Standard Mortality
(2% Discount Rate: Upper Curve is After Tax, Lower Curve is Before Tax)



The second row of Table 1 contains the before- and after-tax Gini indices and the measure of effective progression. Social security again reduces the Gini index, indicating the equalizing effect demonstrated by the Lorenz Curves. The measure of effective progression is 1.05, still greater than one but much smaller than when we used annual income. The reason is that beneficiaries are not as poor as they looked using annual income. With this lifetime concept, the effect of social security is still progressive, but much less so.

As a further measure of progressivity, Figure 2b plots all net social security tax rates, calculated as the present value of expected taxes minus benefits as a percent of the income measure (expected lifetime capped earnings). Progressivity is indicated by the positive relationship in this diagram. Those with low lifetime incomes have large negative tax rates, indicating that they receive net benefits from the system. Most of the very large negative tax rates are those of

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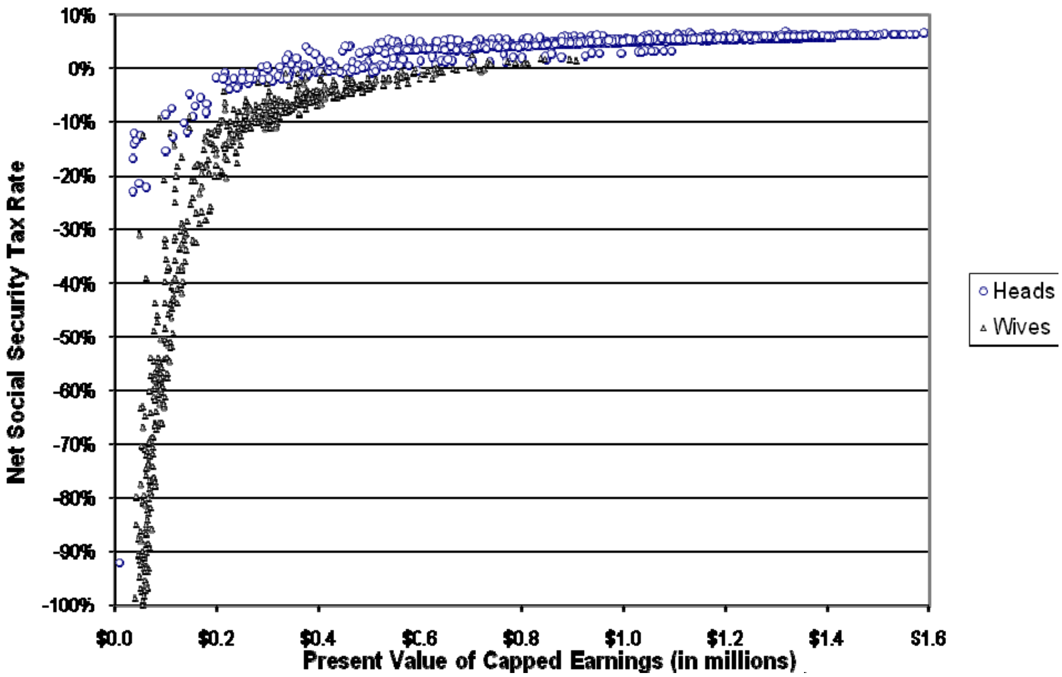
wives who work little and draw a benefit based on their husband's income.[22] As income increases, the net tax rate increases. The relationship between lifetime income and the net tax rate remains positive but flattens out.

Figure 2b
Net Social Security Tax Rate (Tax minus Benefit as a Percent of Income) for Capped Earnings, Standard Mortality, 2% Discount Rate



Step Three: Removing the Cap on Lifetime Earnings

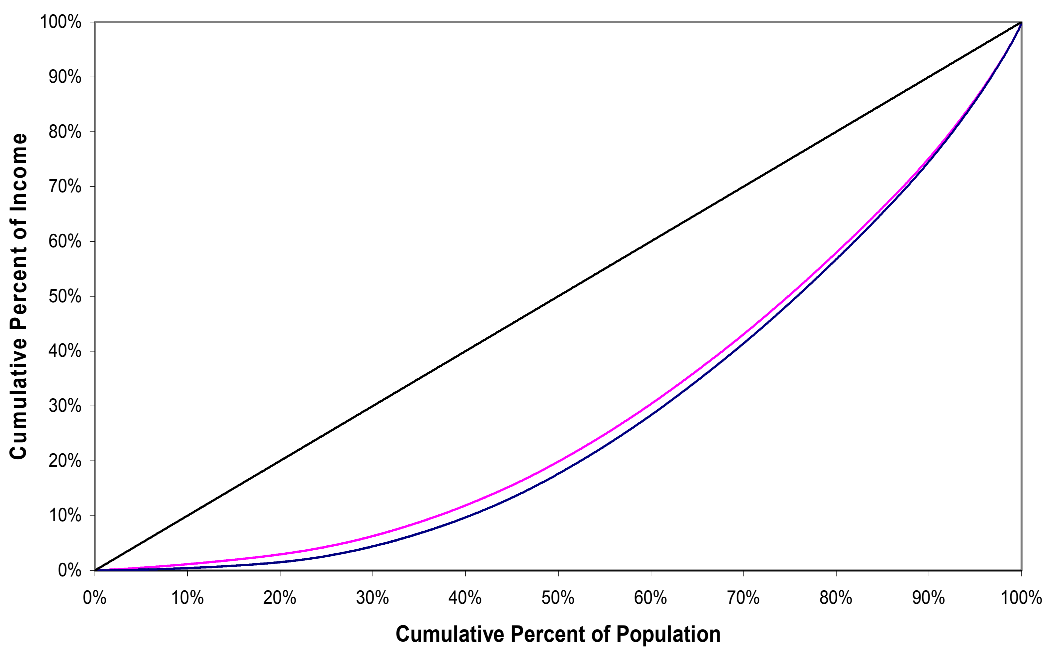
In our next step we remove the cap on earnings and take into account each individual's full lifetime income. The PSID has the advantage over data from social security records that it contains information on earnings that is not top-coded at the taxable maximum. The fact that earnings are taxed only up to a threshold has redistributive implications, despite the fact that benefits are based only on taxable earnings. To see this, consider two individuals: one who earns the taxable maximum over his working life and one who earns twice the maximum. Both pay the same taxes and receive the same benefits, but that positive net tax is

[22] To improve clarity, Figures 2b and 3b do not show negative net social security tax rates greater than 100%. Of the total 1778 points, 163 points below -100% have been censored.

a smaller percentage of lifetime income for the person who earns twice the maximum. Removing the cap on the data regarding lifetime earnings is therefore expected to dampen the measured progressivity of the system.

Figure 3a plots the new Lorenz curves before and after social security, where the income measure is the present value of uncapped lifetime earnings. The after-tax Lorenz curve again lies inside the before-tax curve, indicating the overall progressivity of the system. Then Figure 3b plots net social security tax rates against the present value of lifetime earnings. For a point of reference, a vertical line is drawn at the lifetime income of a person who stayed at the wage cap every year. A few individuals exceed that income. Still, however, much the same pattern emerges as in the case with capped earnings. A cluster of individuals with very low lifetime earnings receive large net transfers from the system relative to their incomes. As lifetime income increases, the tax rate approaches zero and then becomes positive, indicating that the present value of expected taxes exceeds the present value of expected benefits. Although the relationship between tax rates and income is very flat for heads of household at moderate and higher incomes, the system overall still appears to be progressive.

Figure 3a
Lorenz Curves for Uncapped Earnings, with Standard Mortality
(2% Discount Rate, Upper Curve is After Tax, Lower Curve is Before Tax)



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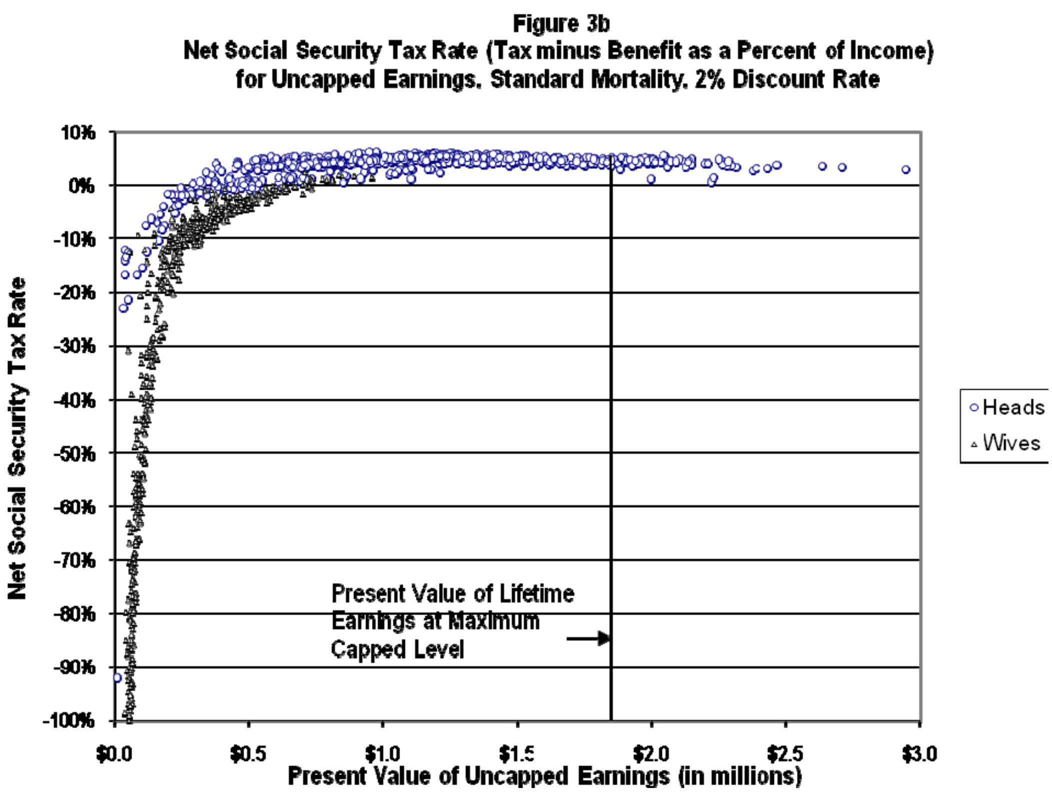
The Gini indices and the effective progression measure are shown in the third row of Table 1. Compared to the previous step that used capped earnings, before-tax income is less equally distributed (the before-tax Gini index rises from 0.3987 to 0.4357). Social security now reduces that Gini from 0.4357 to 0.4076. The effective progression measure is 1.0498, which is less than the earlier case with capped earnings, as expected, but only slightly less.

Brown *et al* (2009) investigate the sensitivity of results to the order of steps, and they find that any step has smaller incremental effects if undertaken after other steps have already dampened the measure of progressivity. However, the order of steps does not change the sign of each effect. The current step removes the cap on wage data and thus accounts for the fact that those with high wages pay a lower rate of FICA tax. While the effect of this step on the *EP* measure is small in Table 1, it would be larger if this step were taken earlier and smaller if taken later in the sequence. With space for more comparisons, we could study the progressivity of social security using only annual income with and without the cap. Here, the comparison of steps 2 and 3 only shows the effect of social security on progressivity using lifetime income with and without the cap.



Step Four: Classification by Potential Income

In evaluating redistribution, we want to classify people from rich to poor based on an appropriate measure of economic well-being. The problem with using actual earnings is that no value is placed on leisure or home production. We now switch to the use of the potential lifetime income concept described in the methodology section to capture our sample members' economic well-being.[23] Here, potential lifetime income is a person's hourly wage rate times his or her annual endowment of 4000 hours. We thus measure redistribution from those with highly valued endowments to those with less, but this kind of redistribution was not the original intent of social security. Nor is it necessarily the proper goal of social security. Rather, the purpose of this exercise is to look at the program from another angle. Policymakers may want to know all the forms of redistribution.

If time at home is due to *in*voluntary unemployment, however, then it should not be valued at the potential wage rate. Still, it should not be valued at zero, either. We cannot distinguish between voluntary and involuntary unemployment, but we explore the importance of this issue by re-computing potential lifetime income with home time valued at half the wage rate.[24]

The individuals most affected by this reclassification are those who spent significant time out of the labor force, either working part-time or not at all. These people are now assigned higher lifetime incomes based on their earning potential. The entire distribution of before-tax lifetime income is now more evenly distributed, and social security is expected to have a less-progressive effect. If people who spend less time in the labor force receive net benefits from the system, such as through spousal benefits, then those benefits will now be seen to go to a person who is not so poor. Measured progressivity will be weakened.

Lorenz Curves before and after social security are plotted in Figure 4a. The before-tax curve lies closer to the equal income line than before, indicating less-concentrated income. The before- and after-tax curves also lie almost on top of each other, indicating that social security redistributes very little when potential lifetime income is used to measure economic well-being. The Gini indices and *EP* measure can be found in the fourth row of Table 1. The lack of redistribution

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[23] After we completed this work, in Coronado *et al* (2000), we found that Gustman and Steinmeier (2001) also use a concept of potential earnings to study progressivity of social security. They cannot capture all of our steps, however, since they study only the benefit schedule and ignore taxes. They use earnings histories that are top-coded, and they employ standard mortality tables.

[24] On the other hand, those with low resources might be more often forced to stay home because of disability, or to care for disabled relatives, or due to involuntary unemployment. If so, then our procedure overstates the value of their time at home, overstates the amount they could earn, and thus understates the progressivity of any transfers to them from social security.

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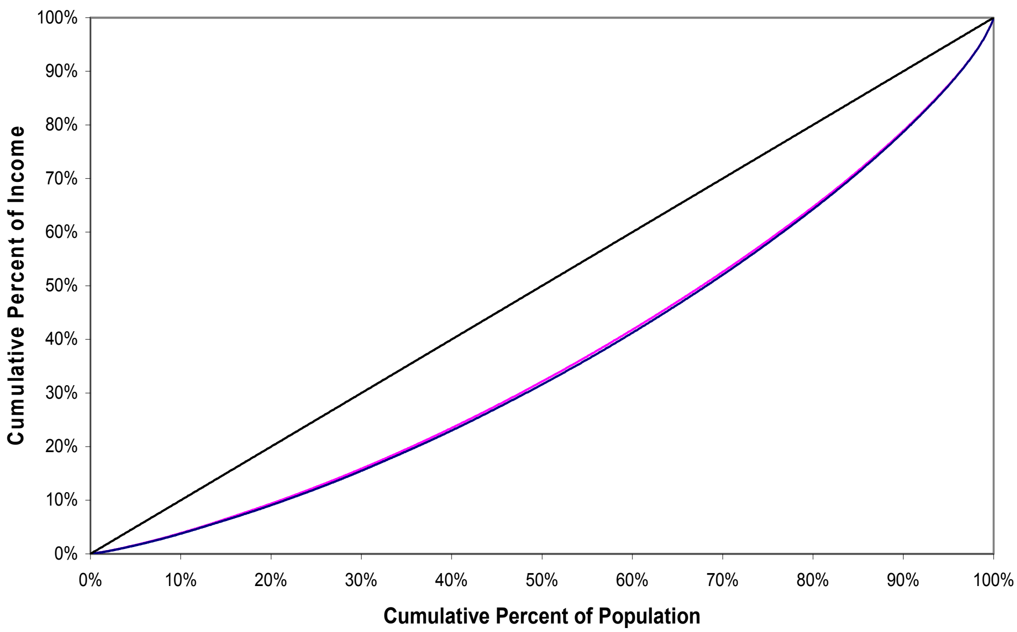
is reflected in the measure of effective progression, which is only 1.01. Social security is only slightly progressive at best.[25]

Figure 4a
Lorenz Curves for Individual Potential Earnings, with Standard Mortality
(2% Discount Rate, Upper Curve is After Tax, Lower Line is Before Tax)

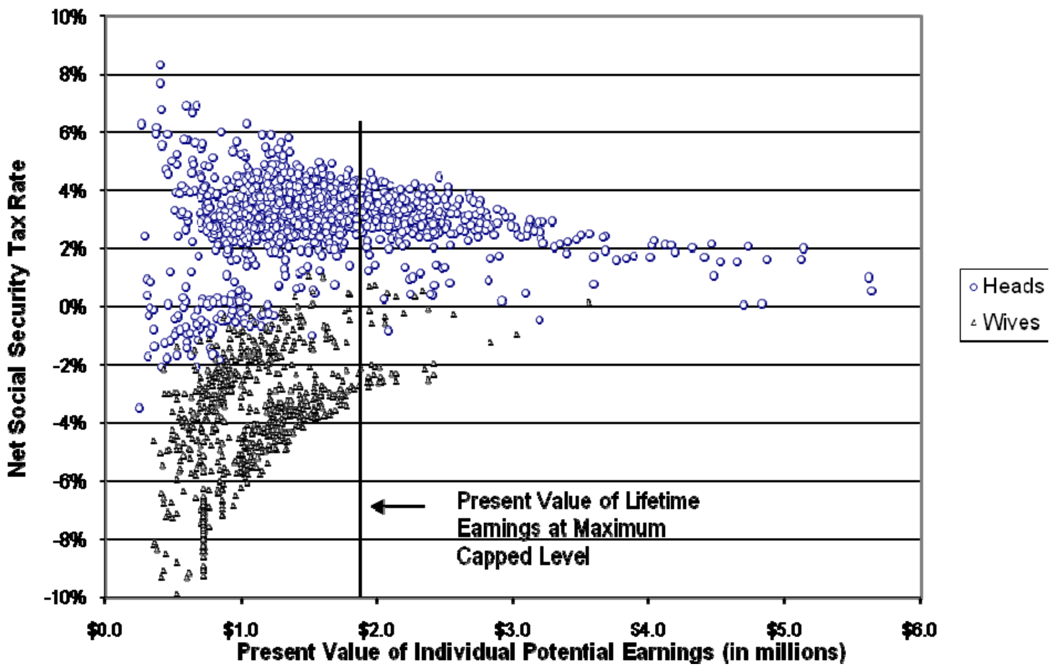


The smooth Lorenz curves hide the variance in the treatment of individuals by social security. Figure 4b demonstrates the widely-divergent net social security tax rates, even at similar levels of potential lifetime income. This scatter plot depicts a very different relationship between tax rates and income than in step three. Since we raise the measured lifetime income of occasional workers, this step eliminates some of the large negative tax rates shown earlier. The removal of those extreme numbers allows an expanded vertical scale that better shows the dispersion in net tax rates at low and moderate incomes. While some with low lifetime incomes receive net benefits from the system, others at the same low lifetime income pay net taxes. In general, wives draw net benefits and heads pay net taxes. Low-earning spouses can draw benefits that are high relative to

[25] Those who choose to stay at home must value their time at the wage they could have earned, but some who do not make a choice may value their time at home at less than their market wage. When we re-compute potential lifetime income with home time valued at half the wage rate, the before-tax Gini is 0.2977, the after-tax Gini is 0.2812, and the *EP* is 1.0234. Progressivity is reduced relative to step three, but not by as much. This answer would differ further to the extent that involuntary unemployment differs across lifetime income groups.

their incomes because of both the spousal benefits and the survivor benefits. A positive relationship between net tax rates and income of wives is still evident in Figure 4b, but it is not very consistent across the population. Because of the way benefits are calculated for different labor supply patterns and marital status, individuals with similar lifetime resources can have different net tax rates.

Figure 4b
Net Social Security Tax Rate (Tax minus Benefit as a Percent of Income) for Individual Potential Earnings, Standard Mortality, 2% Discount Rate



Step Five: Accounting for Household Resource Sharing

Husbands and wives pool their resources, and they therefore have more similar levels of economic well-being than indicated by differences in individual earnings. The policy concern for the poor does not extend to the low-wage spouse of a high-wage earner. We now pool the potential lifetime earnings of married individuals and divide by two, which yields “per capita lifetime household income” as our measure of welfare. This change reduces income for the high-earning spouse and increases it for the low-earning spouse. Thus, the before-tax distribution of income is more equal, and net transfers by social security within a family are not considered part of “redistribution.” We expect social security to have less progressivity.

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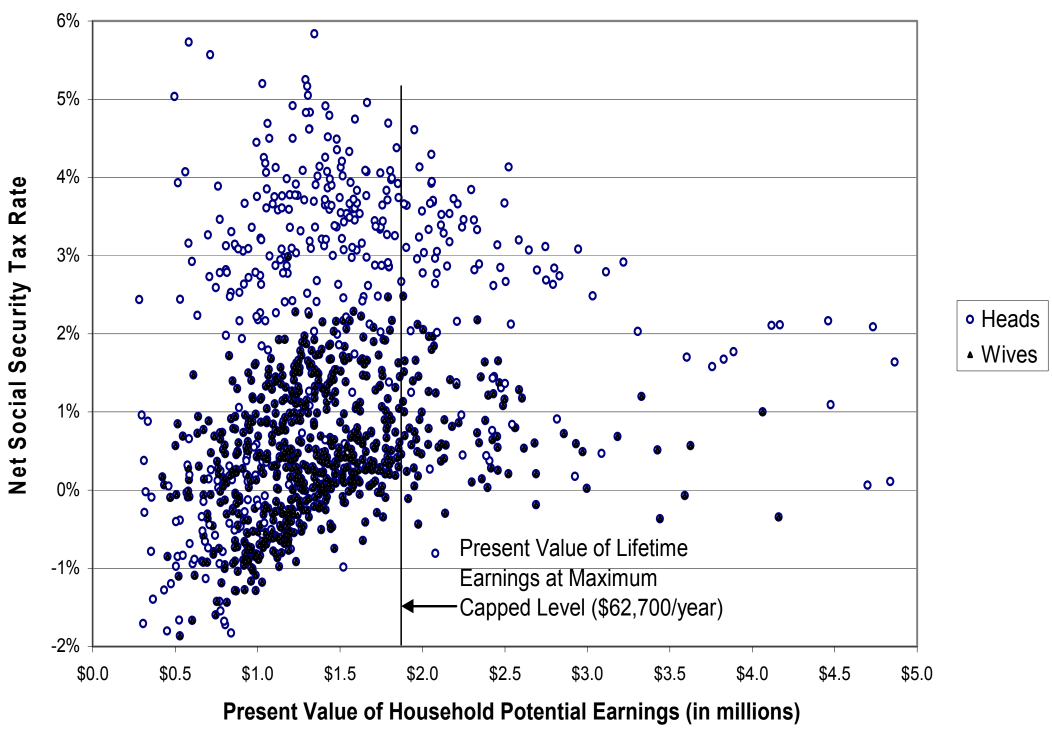
We no longer show Lorenz curves, because the before- and after-tax curves now lie practically on top of each other. The *EP* measure, shown in the fifth row of Table 1, is barely different from one. Progressivity is further weakened through the pooling of household income, and social security appears to be almost neutral with respect to lifetime resources. Figure 5 plots net tax rates against the present value of per capita household potential income. It shows little evidence of a positive relationship between net tax rates and income. The main effect of this step appears to be significantly less negative tax rates for most wives, because low-earning wives are no longer classified as poor.[26]

Figure 5
Net Social Security Tax Rate (Tax minus Benefit as a Percent of Income) for Household Potential Earnings, Standard Mortality, 2% Discount Rate

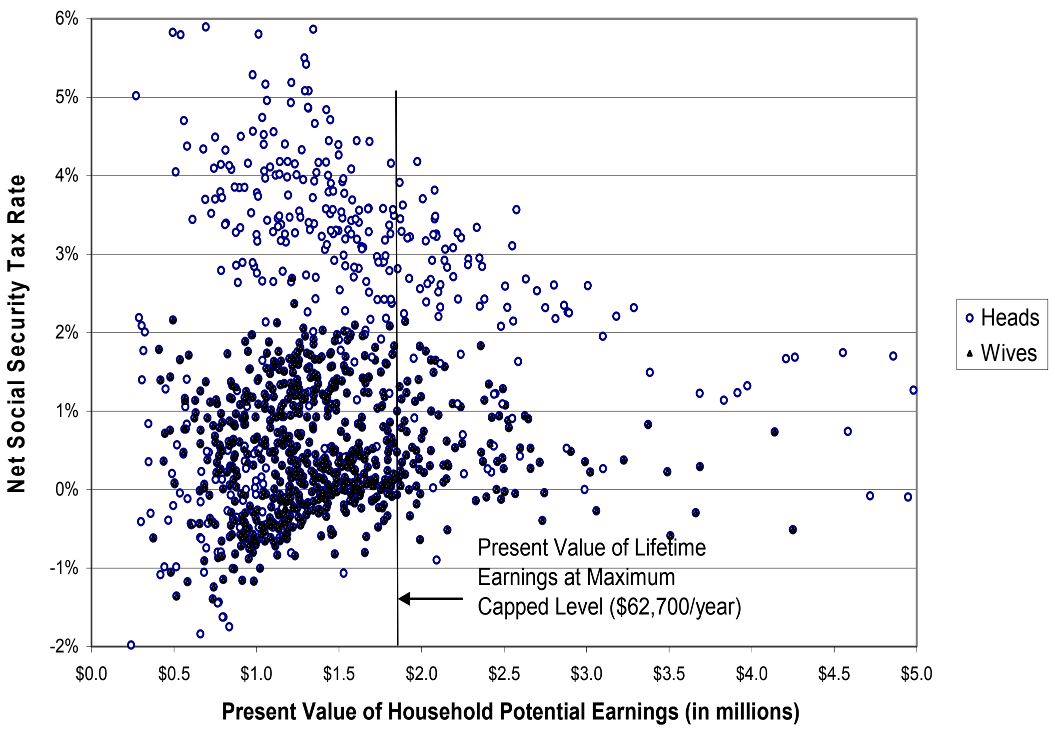


[26] Because husband and wife have the same before-tax and after-tax income, they both have the same net tax rate. Thus the dark triangle for each wife in Figure 5 lies on top of a circle for her husband. The only circles that remain visible are those of unmarried heads of household.

Step Six: Income-Differentiated Mortality

In this step we use the estimated mortality probabilities differentiated by lifetime potential income that were derived in the methodology section. Since the data indicate that individuals with higher lifetime incomes live longer, the expected benefits of high-income people increase relative to those with low incomes, and measured progressivity is expected to decline further. Indeed, the conclusion from prior research is that differential mortality does dampen progressivity.[27]

Figure 6
Net Social Security Tax Rate (Tax minus Benefit as a Percent of Income)
Household Potential Earnings, Income-Differentiated Mortality, 2% Discount Rate



As anticipated, the measure of effective progression shown in the sixth row of Table 1 declines relative to the previous step, but only very slightly (from 1.0024 to 1.0008).[28] Figure 6 plots net tax rates against the present value of per

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[27] Standard tables are differentiated by age, race, and gender, but differentiation by income has been introduced by Aaron (1982), Rofman (1993), Duggan *et al* (1995), Garrett (1995), Panis and Lillard (1996), and Lee, *et al* (1999). Differentiation by education (a proxy for lifetime income) has been introduced by Caldwell, *et al* (1999), Brown (2002), and Liebman (2002).

[28] The effect of any one step necessarily depends on the order of the steps. Previous papers used

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capita household potential earnings. Compared to the previous scatterplot, a negative relationship between net tax rates and lifetime resources appears to be emerging for unmarried household heads. The formerly-positive relationship for married individuals is now flatter. Much of the remaining progressivity of the system appears to come in the form of spousal and survivor's benefits, while the structure in place for primary earners seems to be almost regressive. The treatment of secondary earners balances that of primary earners, and the overall system appears to be basically neutral with respect to lifetime resources.

Step Seven: Increasing the Discount Rate

In our final step, we increase the discount rate used to compute present values of lifetime income, expected taxes, and expected benefits. Caldwell, *et al* (1999) argue that the 2% rate used in much prior literature is too low, because the discount rate should reflect the return that individuals could expect if they invested their contributions in real assets of comparable risk. They argue that the real safe return on indexed Treasury bonds is about 3.5% and that a premium should be added to reflect the riskiness of social security. To account for this argument, we raise the discount rate from 2% to 4%. This change increases the net social security tax rate for everyone, because it increases the weight on earlier payments of payroll taxes relative to later receipt of benefits. Yet payroll taxes are regressive (because of the exemption of wages above the cap), and benefits are progressive (because of the formula). Thus the shift in weight from later benefits to earlier taxes is expected to reduce overall progressivity.

The *EP* measure in row seven of Table 1 is now less than one, which indicates that social security now has a slightly regressive effect in redistributing lifetime resources. The scatter plot in Figure 7 shows that slight regressivity more clearly. Very few individuals actually receive net benefits using the 4% discount rate. The relationship between tax rates and the present value of per capita household potential earnings is clearly negative for unmarried heads of household. It now appears to be flat or very slightly negative for married individuals as well, so that the overall effect of the system is regressive.

III. Income Insurance

By evaluating only the taxes paid and benefits received, we ignore various kinds of insurance value provided by the social security system (Geanakopolos, *et al*,

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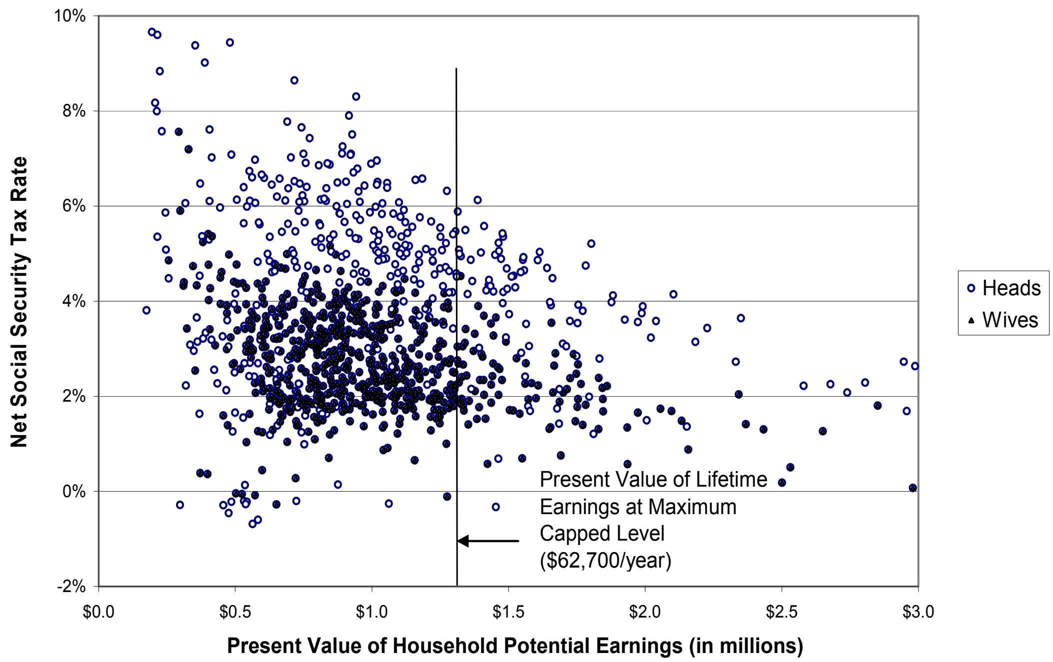
annual income, or actual instead of potential lifetime income. Initial progressivity was higher, and the change to income-differentiated mortality reduced progressivity by more. If we differentiated mortality back at step one or two, we would also obtain a somewhat larger effect.

1999). Different groups may have different risk tolerances and may therefore have different valuations of each type of insurance provided by social security. For example, if lower income individuals have less access to capital and insurance markets that would allow them to insure their consumption stream against a variety of risks, then they might benefit more from the fact that social security reduces the variance of income. We have no risk-averse utility function in our model to calculate the *value* of this risk reduction (as in Mitchell, *et al*, 1999), but we can calculate the *amount* of risk reduction.

Figure 7
Net Social Security Tax Rate (Tax minus Benefit as a Percent of Income)
Household Potential Earnings, Income-Differentiated Mortality, 4% Discount



We look at the variation of annual income within each person's life, both before and after social security. The calculated standard deviation (s.d.) clearly falls more for high income individuals, regardless of our income measure. Thus the absolute amount of risk reduction might rise with income -- another regressive effect. However, those variations are a smaller fraction of income at high income levels. If individuals are concerned with income variations as a fraction of income, then the coefficient of variation (s.d./mean) might better indicate the *value* of risk reduction. In our scatterplots, this coefficient is always reduced more for those with low income -- a progressive effect.

IV. Conclusion

In this paper we seek to measure the extent to which the current social security system redistributes resources from rich to poor. To do so, we build a model that incorporates all the information needed to categorize individuals by alternative definitions of income, to classify individuals from rich to poor. Income may be measured annually or for a lifetime; the data may be truncated at the wage cap; individual or family income may be used to measure well-being; actual or potential income may reflect lifetime resources. For each person, we calculate income, taxes paid, and benefits received from the social security system. We change the definition of income incrementally, to see how each re-definition affects measured progressivity. Ultimately, when individuals are classified as rich or poor based on their command of economic resources, we conclude that the current social security system cannot be considered progressive.

We focus on the retirement portion of social security. By ignoring disability insurance and hospital insurance, we probably ignore the more progressive parts of the program. Disability and hospital benefits likely accrue to those with the highest mortality rates, disproportionately those with low lifetime incomes. We also miss the utility value of risk-reduction from these programs.

Despite these caveats, the results are useful to indicate who receives net transfers from the retirement portion of the program. Different features of our model affect the measured progressivity of the system for different reasons. Using lifetime rather than annual income reduces progressivity because it avoids classifying high lifetime-income elderly as poor. The switch to uncapped earnings demonstrates that some previous studies missed the inherent regressivity of the payroll tax that exempts wages above the cap, because their data only included wages up to the cap. Using potential income reduces progressivity, as those who choose to spend more time on leisure and home production are no longer classified as poor. Pooling resources of husbands and wives has a similar effect, since it increases the measured resources of spouses who did not earn much in the labor force. Using mortality information that differs by lifetime income dampens progressivity slightly, as people with higher lifetime incomes live longer and therefore draw benefits longer. Finally, increasing the discount rate places more weight on regressive payroll taxes relative to the progressive benefits formula, turning the whole system into one that may redistribute from poor to rich.

APPENDIX: DATA AND METHODOLOGY

We estimate log wage regressions in order to predict each person's wage rate in years that are not observed, and then to classify individuals by the present value of their endowment, that is, potential earnings (wage rate each year times 4000 hours). Then, for each endowment quintile, we estimate Tobit regressions for actual earnings, in order to predict earnings out of sample for each individual, and then to calculate social security taxes and benefits in each year of life.

This appendix is divided into six parts, describing the selection of the sample from the PSID, the estimation of log wage regressions and calculation of potential lifetime earnings, the estimation of earnings profiles, the derivation of income-differentiated mortality, the calculation of social security benefits, and the calculation of the Gini coefficient.

A1. Data and Sample Selection

We use the PSID for the years 1968 to 1989, which gives us twenty-two years of data for a sample consisting of 1086 heads and 700 wives that is 66 percent of the representative cross-section.[29] Selection criteria are described in the text. Using a reduced sample suggests the possibility of bias in our econometric estimates and our conclusions about the progressivity of social security. We do not believe our results are biased, however, as Table A1 shows that measured characteristics of our sample are very close to those of the representative PSID sample.

Table A1: Sample Selection

	Original PSID Sample	**Sample Used in Analysis**
Number of people	2780	1786
Percent under 30	36	25
Education of head (percent)		
High school diploma	33	32
College degree	12	12
Education of wife (percent)		
High school diploma	46	50
College degree	8	7
Race of head (percent)		
White	92	94
Black	7	5

A2. Log Wage Regressions and Calculation of Potential Lifetime Income

As our analysis is intended to reflect a steady state, we abstract from real economic growth that occurred during our sample period. We want to isolate life-cycle movements in wages so that our wage profiles are not specific to one

[29] We use these 1786 individuals in the regressions, to generate wage profiles, but we later eliminate 8 outliers (4 couples) and use 1778 individuals in social security calculations.

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generation during a particular time frame. Adjusting for economic growth and inflation yields lifetime wage profiles that can be used to analyze the distributional impact of social security in a more general, structural sense. We therefore adjust the nominal wage rate using the SSA's Average Wage Index, which reflects growth in average nominal wages over the sample period. Using this index to deflate wages removes the effects of both inflation and real growth.

We want to estimate a separate wage regression for the working wives and the household heads, but we question the idea of pooling the positive observations of the wives who work consistently throughout the sample with those who work only occasionally. We found that a woman would have to work at least 750 hours a year throughout her working life, an amount slightly less than half-time, to have her own social security benefits be greater than the spousal benefits she could receive based on her husband's earnings (assuming she earns the same wage as her husband). Thus, we divide the working wives into two groups based on whether or not they averaged at least 750 hours of work per year throughout the sample. We ran our log wage regressions separately for the two groups, and then ran another one pooling the two groups, in order to perform an F-test. The results suggest that these two groups should indeed be analyzed separately. We therefore estimate three log wage regressions: for household heads, habitual working wives, and occasional working wives.

We regress the log of the wage rate on an individual fixed effect and other variables like age, age-squared, and age-cubed. Because we have a fixed effect for each individual, we cannot use variables that do not vary over time (like race or gender). However, we do include age interacted with education, race, and gender. For the heads of household we use all positive observations of wages, which gives us 19,130 observations on our 1086 heads. The results of this regression are shown in Table A2. Using the resulting fixed effects and coefficients, we then fill in missing observations during the sample period and observations outside the sample period so that each individual has a wage rate for every year of their entire economic life from age 22 to 66.

For each of the two groups of working women, we take all positive observations and regress the log of the wage rate on an individual fixed effect and variables for age and the interaction between age and education. The PSID does not have a race variable for the wives in the sample. For the wives who averaged more than 750 hours of work annually, we have 5413 observations on 311 women. For those who work occasionally, but less than 750 hours, we have 2292 observations on 296 wives. The results of the log wage regressions for the two groups of working wives can be found in Table A3. For these two groups, we again use the estimated fixed effects and coefficients to fill in missing observations within the sample, and to simulate observations outside the sample, so that each woman has a complete wage profile. For each of the 93 women who did not work at all, we assign them the median fixed effect from the occasional workers and then use the coefficients from this group's regression to fill in an entire profile of potential hourly wages. Using the wage profile for each individual, we calculate the present value of potential lifetime income. We use this income to delineate quintiles.

Table A2: Log Wage Regression for Heads of Household

Independent Variable	Coefficient	T-Statistic
Age	0.1343	6.26
age^2	-0.003313	-8.53
age^3	0.000026	9.55
age × educ	0.003669	4.87
age^2 × educ	-0.0000326	-4.52
age × female	-0.0239	-1.89
age^2 × female	0.000306	2.11
age × white	0.0167	1.32
age^2 × white	-0.000240	-1.67
Individuals	1,086	
Observations	19,130	
Adjusted R-squared	0.57	

Table A3: Log Wage Regressions for Wives

Independent Variable	Habitual Workers	T- Statistic	Occasional Workers	T-Statistic
age	0.0493	1.25	0.0104	0.102
age^2	-0.000647	-0.949	0.000985	0.522
age^3	0.0000018	0.399	-0.0000111	-1.03
age × educ	-0.000252	-0.106	-0.00538	-0.965
age^2 × educ	0.0000085	0.344	0.0000262	0.419
Individuals		311		296
Observations		5,413		2,292
Adjusted R-squared		0.55		0.36

A3. The Estimation of Earnings Profiles

For each of our five lifetime income quintiles, we estimate three new regressions for actual earnings of heads, habitual working wives, and part-time working wives. In this case, our dependent variable is actual annual earnings. As above,

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we deflate earnings by the SSA's Average Wage Index to adjust for both inflation and real economic growth. Since earnings represent a continuous variable truncated at zero, we use a Tobit framework.

Table A4: Tobit Earnings Regressions for Heads

Independent Variable	(Poorest) First Quintile	Second Quintile	Third Quintile	Fourth Quintile	(Richest) Fifth Quintile
Constant	-8132.46	-30327	-2488.82	-85422.4	-11116
Age	1059.26	1961.75	2389.17	4521.45	6722.26
	(5.50)	(9.92)	(7.82)	(22.55)	(12.54)
Age^2	-13.64	-23.02	-35.43	-50.39	-90.61
	(6.64)	(10.61)	(14.62)	(22.44)	(20.95)
Age × educ			54.67		107.59
			(4.72)		(4.85)
Educ	636.43	2069.38	-3554.69	2811.77	-1912.73
	(6.03)	(4.93)	(2.96)	(3.77)	(1.79)
$Educ^2$	-5.45	-60.97	84.76	-93.01	
	(5.35)	(3.25)	(2.47)	(3.18)	
Female	-15432.5	-36378.6	-8338.69	-7919.65	-28415.5
	(5.46)	(5.73)	(5.80)	(5.05)	(12.22)
Age × female	148.24	548.23			
	(2.73)	(4.53)			
White	1785.82		2505.66	5242.61	13890.8
	(2.63)		(1.91)	(3.59)	(5.19)
Sigma*	15012.6	16429.6	17149.2	18262.5	34386.6
	(81.64)	(85.09)	(84.32)	(89.81)	(92.16)
%positive observations	90%	93%	95%	96%	95%

T-statistics are in parentheses
*Sigma is the standard error of the regression

We judged that the additional programming effort to include fixed effects in our nonlinear Tobit estimation was not worthwhile, given that such estimation also implies inconsistent parameter estimates (Heckman and MaCurdy 1980). By excluding fixed effects in this stage, we are able to include race, gender, and education variables in the earnings regressions without interacting them with age. For each regression for the heads of household, we begin with independent variables for age, age-squared, age-cubed, education, education-squared, the product of age and education, a dummy variable for whether the head is female, age interacted with the female dummy, and a dummy for whether the head is white. We then eliminate variables that are insignificant. The results of the regressions for heads can be found in Table A4. For wives who averaged more than 750 hours of work a year, we begin with age, age-squared, age-cubed, education, education-squared, the product of age and education. We again eliminate the insignificant regressors. Results for these regressions can be found in Table A5. We follow a similar procedure for wives who average less than 750 hours of work per year, and these results can be found in Table A6.

Table A5: Tobit Earnings Regressions for Habitually Working Wives

Independent Variable	(Poorest) First Quintile	Second Quintile	Third Quintile	Fourth Quintile	(Richest) Fifth Quintile
Constant	-14128.3	-4324.5	17493.0	22901.9	29809.2
	(2.53)	(0.59)	(1.18)	(1.11)	(0.54)
Age	1100.17	947.28	-2154.25	-4597.56	-11867.6
	(7.62)	(4.56)	(1.98)	(3.09)	(5.75)
Age^2	-12.60	-15.03	75.45	142.90	333.48
	(9.51)	(7.52)	(2.91)	(3.97)	(6.79)
Age^3			-0.68		-2.85
			(3.44)		(7.56)
Age × educ	10.33	46.05		-1.30	
	(1.38)	(3.74)		(4.64)	
Educ	-1371.47	-1788.95	190.0	3522.4	15155.1
	(2.27)	(3.06)	(1.52)	(3.39)	(2.14)
$Educ^2$	64.97			-88.25	-510.36
	(3.18)			(2.13)	(2.10)
Sigma *	6392.47	8777.5	10216.4	11548.4	15471.3
	(52.55)	(46.22)	(48.26)	(39.36)	(37.76)
%positive observations	84%	83%	84%	85%	84%

T-statistics are in parentheses * sigma is the standard error of the regression

To simulate out-of-sample observations, we multiply the independent variables of each individual by the appropriate coefficients from their group's earnings regression. In addition, we include a random component, which we obtain by using the estimated standard error of each group's regression (shown in Tables A4-A6) to generate a normally-distributed random variable. This random component is intended to represent unforeseen circumstances that affect earnings. It also means that individuals with the same observed characteristics will not have the exact same earnings profile. Simulated earning observations are thus calculated as: $\hat{y}_i = X_i \hat{\beta} + \hat{\varepsilon}_i$, where $\hat{\beta}$ is the vector of estimated coefficients from our earnings regressions, and $\hat{\varepsilon}$ is the random component obtained by using the standard error of the regression to generate a random variable. Using this procedure, both positive and zero observations are generated. We found that

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the number of zeros generated for each group is consistent with the number of zero observations observed for that group during the sample years.

Table A6: Tobit Earnings Regressions for Part-time Working Wives

Independent Variable	(Poorest) First Quintile	Second Quintile	Third Quintile	Fourth Quintile	(Richest) Fifth Quintile
Constant	2738.87	2049.33	-27560.4	-29957	108105
	(1.06)	(0.13)	(2.83)	(5.88)	(4.26)
Age	-68.30	-2970.23	1505.06	739.21	-10479.2
	(1.58)	(3.14)	(5.60)	(5.03)	(5.72)
Age^2		86.98	-16.69	-9.12	267.93
		(4.06)	(5.73)	(5.49)	(6.28)
Age^3		-0.69			-2.156
		(4.30)			(6.69)
Age × educ		-50.12			
		(3.59)			
Educ	-409.04	4947.28	-2579.5	1870.71	1219.79
	(2.96)	(4.24)	(1.78)	(2.59)	(7.05)
$Educ^2$		-119.18	138.56	-58.73	-12.19
		(2.86)	(2.25)	(2.01)	(7.53)
Sigma *	9067.14	6708.64	9759.96	7926.30	12086
	(17.96)	(25.78)	(24.70)	(35.60)	(30.62)
%positive observations	31%	28%	26%	39%	34%

T-statistics are in parentheses * sigma is the standard error of the regression

A4. Derivation of Extended, Income-Differentiated Mortality

To extend the mortality tables from age 85 through age 99, we make three assumptions. First, we assume that the probability of remaining alive beyond age 85 decreases annually by a constant amount (Faber and Wade, 1983). Second, we set to zero the probability of remaining alive after age 99. This age seems a reasonable cut-off point, since less than 0.7% of all social security beneficiaries are older than 95 (*Annual Statistical Supplement, 1997*). Third, given these two conditions, we find the constant annual change in the probability each year for each sex-race group such that the resulting set of probabilities yields the same life expectancy at age 85 as in the V*ital Statistics*.

Table 7 in Rogot *et al* (1992) shows information on actual deaths in their sample for each annual income group, within each race-sex-age group. For example, consider white males, ages 25 to 34. For each range of income (e.g. $10,000 to $14,999 in 1980 dollars), their table shows the number of individuals in their sample (*N*=14,563), the number of observed deaths during the sample period (*O*=115), and the number of deaths that would be expected if all income groups had the same mortality rate (*E*=92.2). They then divide to get the Observed/Expected ratio (*O*/*E*=1.25). Actual deaths in that low-income group are 25% higher than would be expected using tables not differentiated by income.

We know the annual income of every individual in our PSID sample, so we need to exclude the "unknown income" category from the table in Rogot *et al* (1992). If we simply ignored this category, the overall *O*/*E* ratio would not be 1.0 for all income groups together. For this reason, we recalculate the expected deaths based on the subset of their individuals for which income is known, and recalculate *O*/*E* ratios for each group. The average of these new *O*/*E* ratios is 1.0, as desired. We then apply the appropriate ratio to each cell. Results for 25-34 year olds are shown in Table A7.

Table A7: Ratio of Observed Deaths to Expected Deaths (*O*/*E*) for Each Race-Sex Group, Ages 25-34

Annual Family Income	Number (*n*)	Percentile	*O*/*E* White Male	*O*/*E* White Fem.	*O*/*E* Other Male	*O*/*E* Other Fem.
< $5,000	11,670	6.31%	1.68	1.51	1.54	1.86
$5,000 - $9,999	22,085	18.25%	1.20	.97	.81	1.01
$10,000 - $14,999	33,331	36.27%	1.28	1.17	1.36	1.01
$15,000 - $19,999	32,231	53.70%	1.12	.76	.71	.84
$20,000 - $24,999	30,729	70.31%	.80	.97	.92	.36
$25,000 - $49,999	48,375	96.47%	.73	.94	.72	.44
> $49,999	6,529	00.00%	.61	1.15	.72	.44
Totals	184,950		*n* = 81,461	*n* =85,047	*n* =7,752	*n* = 10,690

Source: Rogot, *et al* (1992), Table 7. The "expected" number of deaths is based on the overall death rate within the age-sex-race category, not differentiated by income, while "observed" deaths are the actual number of deaths in each income group.

Finally, since annual income is volatile, we do not want to apply these annual-income-differentiated *O*/*E* ratios to the annual income of each person each year. Instead, we base differential mortality on lifetime income, in three steps. First, after we compute the present value of lifetime income for each of the 1,786

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in our PSID sample, we assign each individual a ranking compared to all individuals in our sample. For example, an individual whose lifetime income ranks 432 out of the 1,786 individuals is ranked in the 24th percentile. Second, for each of the annual income groups in Table A7, we likewise determine percentile rankings based on income (shown in the third column). Third, for each individual in our sample, we match the percentile of their lifetime income to the percentile for the same age-race-sex category in Table A7. For example, a white female aged 27 who has lifetime income at the 24th percentile would be matched to the $10,000-$14,999 annual income group (which lies between the 18th percentile and the 36th percentile). That individual would then be assigned that group's O/E ratio for white females (1.17). Finally, this ratio is used to scale the probability of death for that individual, from her age, sex, and race category in the *Vital Statistics* (which are not differentiated by income).

A5. Calculation of Social Security Benefits

Every variable in this appendix is specific to each individual, but we drop the index i for expositional simplicity. For an unmarried individual, the social security benefit at age j is:

$$BEN_j = PIA_j \times CPI_{62,j}$$

where PIA is the Primary Insurance Amount, $CPI_{62,j}$ is the cumulative inflation index from age 62 to the age at which the benefit is computed. Then the mortality-adjusted benefit is:

$$E_{22}(BEN_j) = BEN_j \times P_j$$

where $E_{22}(BEN_j)$ is the expected value at age 22 of the benefit to be received at age j, and P_j is the conditional probability of survival to age j, given survival to age 22. For married individuals, the basic benefit is computed in the same manner. We compute the spousal benefit for the wife (or analogously, the husband) as:

$$SpBEN_j = 0.5 \times SBEN_{js} \;,$$

where $SpBEN_j$ is the spousal benefit at wife's age j, $SBEN_{js}$ is the husband's PIA adjusted for inflation to age js, and js is the husband's age when the wife is age j. Similarly, we calculate the survivor benefit:

$$SurvBEN_j = SBEN_{js}$$

where $SurvBEN_j$ is the wife's survivor benefit after the death of the husband. If the other spouse is alive, we assume that a married individual receives the greater of his or her own benefit (*BEN*) or the spousal benefit (*SpBEN*). If the other spouse is deceased, the individual receives the greater of his or her own benefit (*BEN*) or the survivor benefit (*SurvBEN*). Using PH_j and PW_j for the husband's and wife's survival probabilities, the husband's mortality-adjusted benefit is:

$$E_{22}(HBEN_j) = PH_j[PW_j\text{Max}(BEN_j, SpBEN_j) + (1\text{-}PW_j)\text{Max}(BEN_j, SurvBEN_j)]$$

where $E_{22}(HBEN_j)$ is the expected value at age 22 of the husband's benefit. This expected value includes only the dollars going directly to husband. A symmetrical calculation is made to determine the wife's benefit:

$$E_{22}(WBEN_j) = PW_j[PH_j\text{Max}(BEN_j, SpBEN_j) + (1\text{-}PH_j)\text{Max}(BEN_j, SurvBEN_j)]$$

We then compute the present value of expected taxes and benefits at age 22 for each individual, using alternative values for the constant real discount rate r:

$$PVTAX = \Sigma_j[E_{22}(SST_j)/(1+r)^{(j\text{-}22)}] \;,$$
$$PVBEN = \Sigma_j[E_{22}(BEN_j)/(1+r)^{(j\text{-}22)}] \;.$$

A6. Calculation of the Gini Coefficient

Our progressivity measure is based on the Gini index. The Suits (1977) index has been used to measure progressivity, but it requires that all taxes be nonnegative. In our study, the net tax can be either positive or negative. We also considered welfare-based measures of progressivity such as the Blackorby-Donaldson (1983) Index and the Kiefer New Progressivity Index (Kiefer, 1984), but those require everyone to have positive income. In our data, some individuals have no income, so welfare would be zero and progressivity would be undefined.

Mechanically, a Lorenz curve is constructed by first ordering all individuals in the population by income, from lowest to highest, and then computing for each individual (a) the cumulative income for all individuals in the population up to and including the individual, and (b) the cumulative population up to and including the individual. These cumulative amounts are normalized to percentages of the total cumulative incomes (total population), and a curve is constructed. Since they are fractions of totals, the x- and y- axes both have limits of (0,1), and the area of the box is 1.0. Any distribution of income other than strict equality results in a Lorenz curve that is continuous from (0,0) to (1,1) and is on or below the equal income line at all points.

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For computation of the Gini Index, think of the Lorenz curve as a histogram. The bars of the histogram rise in height for each consecutive individual. The total area of the histogram is the sum of the areas of all of these bars. Each bar has width 1/*N*. This area is calculated as:

$$A_{LC} = \sum_{i=1}^{N} \frac{\sum_{j=1}^{i} Y_j}{\sum_{k=1}^{N} Y_k} \frac{1}{N}$$

where i indexes individuals who are ranked by income from lowest to highest, N is the total number of people, and Y is income. Since the total area under the equal income line is 0.5, the area between the equal income line and the Lorenz curve is $0.5 - A_{LC}$. Thus the Gini Index is:

$$Gini = \frac{0.5 - A_{LC}}{0.5}$$

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