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Estimating Intensive and Extensive Tax Responsiveness

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ESTIMATING INTENSIVE AND EXTENSIVE TAX RESPONSIVENESS: DO OLDER WORKERS RESPOND TO INCOME TAXES?*

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Abstract

This paper studies the impact of income taxes on intensive and extensive labor supply decisions for older workers. The literature provides little evidence about the responsiveness of the older population to tax incentives, though the tax code is a potentially important mechanism for affecting retirement behavior. We estimate the intensive and extensive margins jointly with a new approach accounting for selection into labor force participation. On the extensive margin, we find substantial effects of income taxes on labor force participation and retirement decisions, estimating participation elasticities with respect to after-tax labor income of 0.76 for women and 0.55 for men. About half of the magnitude of these labor force participation elasticities are associated with tax-driven reductions in retirement. We find statistically insignificant compensated elasticities on the intensive margin. We simulate the effects on labor supply of two possible age-targeted tax reforms. We find that eliminating the employee portion of the payroll tax at age 65 would decrease the percentage of workers exiting the labor force by 6-7%. An EITC expansion which extends the tax credit to older ages (irrespective of their number of dependents) would decrease the probability that workers exit the labor force by 3 percentage points for men and by 6 percentage points for women, reductions of 11% and 23% from baseline rates.

Keywords: Retirement, Income Taxes, Selection Models
JEL classification: H24, J20, J26

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1 Introduction

Economists and policymakers have long been interested in understanding the effects of economic incentives on the retirement decisions of older workers. Delaying retirement and extending working lives has important consequences for the financial viability of Social Security and the overall productivity of the economy (Maestas and Zissimopoulos (2010)) while also improving the welfare of older individuals as additional labor earnings supplement savings and Social Security benefits.[1] Due to the potential benefits of systematic delays in retirement, there are large literatures investigating the labor consequences of Social Security benefits (see Feldstein and Liebman (2002) for a review), pensions (e.g., Samwick (1998); French and Jones (2012)), and Medicare (e.g., Blau and Gilleskie (2006); French and Jones (2011)). However, one issue that has been largely unexplored in the traditional retirement literature is the effect of income taxes on retirement decisions. Income taxes affect individuals' incentives to work and, as such, the tax code is a potentially useful, but generally overlooked, policy lever to encourage individuals to earn more and remain in the labor force longer.

In general, the United States tax code treats older and younger individuals alike, with a few small exceptions such as the age 65+ deduction and elimination of the Earned Income Tax Credit (EITC) at age 65. However, some have suggested scope for more age-targeted tax policy. Banks and Diamond (2010) in the Mirrlees Review recommend increasing the age dependence of taxes, calling the idea "a case of theory being ahead of policy, with research on tax design needed." Meanwhile, some economists have recommended eliminating the payroll tax after certain ages or after Social Security receipt (Biggs (2012); Laitner and Silverman (2012)), and the elimination of income taxes for seniors earning less than

[1]Butrica, Smith, and Steuerle (2006) estimate that an additional year of work increases annual retirement income by 9%, with even larger returns for low-income individuals.

$50,000 was proposed by Barack Obama in the 2008 presidential election.[2] Reznik, Weaver, and Biggs (2009) estimate that individuals ages 62-65 can expect only 2.5 cents for every additional dollar paid into Social Security; thus, elimination of the payroll tax at older ages could drastically change the incentives for individuals to remain in the workforce.[3]

Furthermore, since age is an observable variable that likely proxies for different levels of productivity and attachment to the labor market, "tagging" by age may also improve redistributive taxation (Akerlof (1978)). A small literature has estimated calibrated life-cycle models and found substantial welfare gains when taxes are age-dependent. Weinzierl (2011) concludes that age-dependent labor income taxes lead to "substantial increases in both efficiency and equity." Weinzierl (2011) assumes that tax responsiveness is uniform across age, but notes that differential elasticities could have important implications for such welfare calculations. Karabarbounis (2013) also estimates a calibrated life-cycle model and finds that age-dependent taxes have large effects on the labor supply of older individuals.[4] Despite the theoretical possibilities of age-dependent taxes, there is scarce evidence on the behavioral responses to income taxes for older individuals.

A large literature estimates the effects of taxes on labor supply (summarized in Keane (2011)) and taxable income (summarized in Saez, Slemrod, and Giertz (2012)). These studies generally explicitly exclude older individuals from the analysis or estimate aggregate effects combining all age groups. Consequently, there is almost no empirical evidence on the extent to which older individuals respond to taxes. An exception is Laitner and Silverman (2012) which estimates a structural life-cycle model to simulate the effects of eliminating the

[2]See http://change.gov/agenda/seniors_and_social_security_agenda/ (accessed October 21, 2013)

[3]Moreover, compared to policies that aim to extend working life by reducing access to retirement benefits, such as increasing the normal retirement age for Social Security, age-dependent tax incentives may have better welfare consequences for individuals with health-related work limitations (Schimmel and Stapleton (2010)).

[4]Karabarbounis (2013) assumes exogenous retirement at age 65. The model estimates that optimal Ramsey taxation implies lower tax rates at age 50+ because older workers in the model are especially responsive to taxes on the extensive margin.

payroll tax for older individuals on retirement behavior.

Estimates of labor supply elasticities derived from younger or aggregate populations may not be generalizable to older individuals for a number of reasons. First, differences in health status could affect labor supply preferences and older workers may have different levels of productivity. Moreover, due to pensions and Social Security, this group may be receiving a regular stream of unearned income, thus behaving more similarly to "secondary earners," for whom taxes have been shown to have a larger effect (Saez, Slemrod, and Giertz (2012)). Social norms about retirement behavior may also alter the impact of incentives to continue working (Behaghel and Blau (2012)).

In this paper, we aim to fill this significant gap in both the retirement and tax literatures by providing some of the first estimates of the effects of income taxes on both the intensive and extensive margin labor supply decisions of older workers. We use the 2000-2010 Health and Retirement Study (HRS) which provides the most detailed information available on earnings, employment, and retirement for a panel of individuals over the age of 50. Given that labor supply decisions directly affect tax liability, we exploit variation in federal income tax rates originating from two major legislative tax schedule changes that occurred during this time period (Economic Growth and Tax Relief Reconciliation Act of 2001 and Jobs and Growth Tax Relief Reconciliation Act of 2003) to estimate causal effects. These policies had large effects on the tax incentives that some individuals faced while leaving others less affected. A rich tax literature has used tax schedule changes to identify behavioral responses to taxes for the aggregate or younger populations (e.g., Auten and Carroll (1999); Gruber and Saez (2002)) and a number of studies have found economically meaningful aggregate behavioral responses to tax policies during our study period (see Giertz (2007); Auten, Carroll, and Gee (2008); Heim (2009); Singleton (2011); Saez, Slemrod, and Giertz (2012)).

Because tax rates and earnings are mechanically linked, the elasticity of taxable income (ETI) literature has often instrumented for marginal tax rates using variation from tax reforms. Given non-linear tax schedules, tax reforms often generate differential changes in marginal tax rates across tax brackets. Many studies have exploited this variation to compare changes in earnings for households in tax brackets that experienced large changes in marginal tax rates relative to households in brackets that experienced smaller or no changes. In practice, the instrument is computed by predicting the change in the marginal tax rate that the household faces before and after the reform, holding everything else constant including real income and household characteristics. We adopt a similar strategy which relies on the differential effects of tax code changes. The literature, however, has noted the potential problems caused by mean reversion and secular income trends so we modify the strategy to account for these concerns more explicitly.

Gruber and Saez (2002) (and subsequent studies) also use the nonlinearities in the tax schedule to decompose the behavioral response to tax reforms into substitution and income effects. Because of the nonlinearities, different households may experience different predicted changes in their marginal tax rates. Moreover, even two households with the *same* predicted change in their marginal tax rates may experience different predicted changes in their after-tax income, permitting separate identification of the income effect from the substitution effect (described in detail in Section 4.2.1). This decomposition applies to intensive margin behavioral decisions, which are the primary focus of the ETI literature and the male labor supply literature. We add to these literatures by recognizing that these nonlinearities can also be used to separately identify yet another important dimension: tax-based incentives to participate in the labor force. This additional identified term permits us to estimate extensive margin labor supply effects, which are of particular importance for older individuals. Specifically, we show that two people predicted to experience the same change in their marginal tax rates and the same change in their after-tax income may experience different changes in their after-tax *labor* income (which represents the after-tax incentives to work), separately identifying the after-tax incentive to work from the income effect and the intensive margin substitution effect (described in detail in Section 4.2.2).

Estimates of intensive margin effects of taxes on labor earnings may be biased if self-selection into employment is endogenous to tax incentives and this selection is not accounted for. One methodological contribution of this paper is to use the insight that we can separately identify the after-tax incentive to work as a way to account for selection into labor force participation when estimating intensive margin labor supply. This approach may be useful more broadly for accounting for selection in labor supply models. We model labor earnings as a function of the marginal tax rate and after-tax income. Labor force participation is modeled as a function of the additional after-tax income due to working (after-tax labor income), a variable excluded from the intensive margin equation. This suggests a powerful new instrument that affects selection into labor force participation, but does not – conditional on the marginal tax rate and after-tax income – independently affect intensive labor supply outcomes. We use policy-induced changes in after-tax labor earnings as an excluded instrument to correct for selection using both the standard Heckman method and a semi-parametric approach. The labor literature has struggled to find appropriate instruments for selection models, often using the number of preschool children in the household to identify the selection term (e.g., Eissa and Hoynes (2004)). We introduce a new instrument for labor force participation which plausibly satisfies the exclusion restriction required by selection models.

Implementation of this approach requires joint estimation of the intensive and extensive margin equations. By estimating both equations together, we bridge two important tax and labor literatures that have typically estimated these margins separately. On the one side, the ETI literature and the male labor supply tax literature estimate primarily intensive margin effects. These studies implicitly assume that selection into the sample is random.[5] As noted in the review of the labor literature by Keane (2011), "it is common to ignore selection on the grounds that the large majority of adult non-retired men do participate in the labor market...Whether selection is really innocuous is unclear, but this view is adopted in almost all papers on males that I review." Intensive margin decisions for women are less frequently studied.

On the other side, a related labor literature on the labor supply of women or secondary earners studies primarily extensive margin labor supply decisions – relating the pecuniary incentives to work to the probability of working. This literature frequently notes that the main explanatory variable of interest (after-tax labor income) is not observed for non-workers and must be imputed. Eissa, Kleven, and Kreiner (2008), for example, impute after-tax labor earnings using a selection model with the assumption that the number of preschool children is a shock to selection into working that does not independently affect after-tax earnings. Meyer and Rosenbaum (2001) and Blau and Kahn (2007) impute tax burdens and wages, respectively, if an individual works by assuming that workers and non-workers are similar conditional on observable characteristics.

Our approach, estimating the intensive and extensive equations jointly, addresses many of the issues that each of these literatures have faced when estimating one equation in isolation. Our method contributes to the intensive margin literature by accounting for selection with a plausibly exogenous shock to participation based on participation-specific tax incentives to work. Furthermore, our method recognizes that consistent estimation of the intensive margin equation allows for consistent predictions of labor earnings for both workers and non-workers. These predictions of labor earnings and corresponding calculations of tax burdens given those labor earnings permits construction of the after-tax labor income

[5] The ETI literature typically selects on households with a minimum level of income in each period so selection is potentially important.

variable for the extensive margin equation. Estimating both margins jointly allows us to obtain consistent estimates of the effects of taxes on both labor earnings and the decision to work or retire.

We use our estimates of the tax elasticity of labor supply for older individuals to model two age-targeted policy experiments. First, we consider a policy which eliminates the employee portion of the Social Security payroll tax for older workers. The payroll tax is an example of a tax that could easily be altered to exclude people by age or eligibility for Social Security. Social Security taxes can imperfectly be viewed as a forced savings mechanism for the prime-age working population. However, for older workers, it is almost a pure tax since individuals can only expect to receive a small share of what they pay into Social Security (Reznik, Weaver, and Biggs (2009)).

The second policy that we model is an expansion of the Earned Income Tax Credit (EITC), currently available to non-elderly workers, to include older workers without dependents. A similar policy is discussed in Schimmel and Stapleton (2010) for older workers with health-related work limitations. The EITC subsidizes labor earnings with a subsidy schedule that is non-linear in earnings. We model a policy which applies the most generous existing EITC schedule (the schedule applied to households with three children) to the older population, irrespective of their number of dependents.[6] This policy has the potential to substantially increase the incentives to work and delay retirement. At younger ages, the EITC has been shown to have significant effects on labor force participation (Meyer and Rosenbaum (2001), Eissa and Hoynes (2004)).

Our results suggest that taxes have a statistically significant and economically large impact on labor force participation and retirement decisions for older workers. On the extensive margin, we find statistically significant and economically meaningful effects on the

[6] EITC eligibility is also determined by several other factors which we will assume would also be relaxed when expanding to older ages.

probability of working. The estimated participation elasticity with respect to after-tax labor earnings is 0.548 for men and 0.755 for women. We benchmark these estimates to those found in Eissa and Hoynes (2004) for the 25-54 population and find that the elasticities for the older population are larger than those for the younger population. Our estimates suggest substantial scope for affecting labor force participation decisions of older workers through the tax code.

Furthermore, we find significant effects on the retirement margin. 53% of the extensive margin effect for women is associated with retirement while 36% of the participation effect for men is associated with retirement. These results suggest that tax changes may have more permanent effects on the labor supply of older individuals.

The elimination of the employee portion of payroll taxes for older workers is estimated to decrease the percentage of both men and women exiting the labor force by almost 2 percentage points, a 6-7% decrease. The EITC expansion has even larger effects. Expanding the EITC to older ages would decrease the percentage of men exiting the labor force by 3 percentage points, an 11% decrease. For women, we estimate a decrease in the probability of labor force exits of 6 percentage points, a 23% decrease. On the intensive margin, we find little evidence that labor earnings for individuals ages 55-75 respond to the marginal net-of-tax rate, the amount that a worker keeps for an additional $1 in earnings. However, our intensive labor supply estimates have large confidence intervals and it is also difficult to rule out large elasticities.

In the next section, we further discuss how this paper is related to previous research in the tax and labor supply literatures. Section 3 describes the data and Section 4 includes the model and empirical strategy. We present our results in Section 5. Section 6 concludes.

2 Related Literature

This paper intersects with the literatures on retirement and the literatures on the elasticity of taxable income (ETI) and labor supply. Because extensive margin effects are especially relevant for the older population, we also highlight this paper's placement in the literature on the effects of wage and tax incentives on labor force participation. Above, we noted the wealth of policies and incentives studied in the retirement literature. We contribute to this literature by studying a potentially important and understudied factor in retirement decisions – the tax code – which directly alters labor supply incentives.

A rich literature studies the effect of changes in marginal tax rates on taxable income. Our empirical approach is closely related to Auten and Carroll (1999) and Gruber and Saez (2002) which take advantage of the differential effects that the Tax Reform Act of 1986 (TRA86) and other legislative tax schedule changes had on households. In these papers, the authors instrument for the change in the marginal net-of-tax rate using its predicted change assuming that household real income stays constant from one period to the next. Variation in the marginal net-of-tax rate originates from federal (and/or state) tax schedule changes. Due to the non-linear tax schedule, households experience different tax rate changes depending on their baseline income. Particular innovations of Gruber and Saez (2002) were to control flexibly for initial income due to concerns about mean reversion and the correlation between secular trends in income and tax rate changes. They also, notably, used tax schedule changes to separately identify the substitution and income effects so that the effect of the marginal tax rate can be interpreted as a compensated elasticity. We build on this literature by recognizing that tax schedule changes can also separately identify changes in the incentive to participate in the labor force, which is useful for estimating both intensive and extensive margin labor supply effects. Furthermore, the ETI literature has never focused on older individuals. Auten and Carroll (1999) limit their sample to ages 25-55, Feldstein (1995) excludes individuals over age 65, and the majority of the other studies mentioned previously estimate responsiveness for an aggregate population.

A related literature has studied the effects of taxes and wages on labor supply, typically measured as hours worked or labor force participation. This literature - summarized in Hausman (1985a), Blundell and MaCurdy (1999), and Keane (2011) - typically finds that women are very responsive to taxes and wages, while prime-aged men are not. In general, this literature does not study older workers and frequently even eliminates them from the analysis. Many influential studies have selected on individuals by age, usually using a maximum cutoff of 50, 55, or 60.[7] It is unlikely that these elasticity estimates could be extrapolated to an older population.

This paper also builds on the subset of papers in the above literature focusing on extensive margin decisions and modeling such decisions as a function of the pecuniary return to working. For those not working, this literature imputes wages or total earnings as if they had worked. Typically, the literature predicts wages or earnings by assuming that workers and non-workers are the same conditional on covariates (see Meyer and Rosenbaum (2001) and Blau and Kahn (2007)). Eissa and Hoynes (2004) and Eissa, Kleven, and Kreiner (2008) use selection models to impute earnings for non-workers. The excluded variable identifying the selection equation is the number of children and presence of young children in Eissa and Hoynes (2004) and the number of preschool-aged children in Eissa, Kleven, and Kreiner (2008). We build on this framework, but improve on the identification of the selection equation using a new instrumental variable for older individuals which is derived from nonlinearities in the tax schedule. This strategy offers credibly exogenous variation in the selection mechanism. Furthermore, we test the robustness of our results by using

[7]See, for example, Hausman (1985b); Blomquist and Hansson-Brusewitz (1990); Triest (1990); Eissa (1995); Blundell, Duncan, and Meghir (1998); Ziliak and Kniesner (2005); Blomquist and Selin (2010) which are just a small subsample of these studies.

methods that do not impose the strong distributional assumptions of conventional selection models used in the literature.

One literature which specifically addresses labor supply effects for older workers is the literature studying the effects of the Social Security Annual Earnings Test (Friedberg (2000); Gruber and Orszag (2003); Song and Manchester (2007); Haider and Loughran (2008); Gelber, Jones, and Sacks (2013)). Findings in this literature are mixed with some evidence that Social Security recipients are responsive to the earnings test on the margin of labor earnings. Recent evidence (Gelber, Jones, and Sacks (2013)) finds large behavioral responses. Given that the earnings test is not a pure tax since it returns the benefits in an actuarially fair manner, it is possible that individuals' responsiveness to a pure tax may be even larger.

Finally, most relevant to our study, Laitner and Silverman (2012) simulates the effects of eliminating the payroll tax for older ages and concludes that this policy would delay retirement by, on average, one year. To our knowledge this is the only other paper that studies the effects of tax incentives on the labor supply of older workers. This work estimates a life-cycle model using data on consumption, work-limiting disabilities, and labor supply. Our paper takes a different approach and uses tax policy changes as a source of identification, providing the first "quasi-experimental" evidence of the impact of taxes on the labor supply decisions of older individuals. While a structural life-cycle model explicitly considers the dynamic aspects of labor decisions in response to income taxes and complementarities with consumption, our approach does not require - for example - assuming a household utility function or modeling disability trajectories. Instead, we study the observed labor outcome changes resulting from legislative tax changes.

3 Data

We use the Health and Retirement Study (HRS) as our primary data source. The HRS is a panel data set of individuals ages 51 and over, containing a rich set of variables including detailed demographics, income, and labor supply variables. The HRS interviews survey participants and their spouses every two years. We exploit the panel nature of the data in our empirical strategy by using differences to account for unobserved individual heterogeneity.

The highly detailed income variables are also crucial for generating tax variables. We use NBER's TAXSIM program (Feenberg and Coutts (1993)) to derive tax rates, tax liability, and labor taxes for each individual based on their household income and family characteristics. The HRS income, asset, and demographic variables used as inputs to TAXSIM are taken from RAND generated tax data files which produce cleaned and consistent definitions across years.[8] We use federal taxes plus one-half of FICA taxes in our calculations of tax rates and tax liability.[9]

We use the 2000-2010 waves of the HRS in our analysis. The labor earnings, income, and derived tax variables refer to the previous calendar year so our final sample includes data from tax years 1999, 2001, 2003, 2005, 2007, and 2009.[10] We restrict our sample to include everyone ages 55 to 75 who works in period t linked to their outcomes in period $t+1$. Given the structure of the data set, we use 2-year intervals in our specifications[11] and refer to

[8]See RAND Contributions at http://hrsonline.isr.umich.edu/ for tax files for 2000 and 2002; 2004-2010 tax files were obtained directly from RAND.

[9]TAXSIM includes the age 65 deduction when applicable but, otherwise, does not use age information when calculating household tax information. Consequently, TAXSIM will assign the EITC to individuals ages 65+. We use the TAXSIM calculations of the EITC and subtract these values for individuals age 65 or older.

[10]A small number of individuals were interviewed in the following calendar year and their annual income variables refer to 2000, 2002, 2004, 2006, 2008, or 2010. We exclude these observations from the analysis.

[11]Gruber and Saez (2002) find little evidence that interval length changes the estimates in a meaningful manner. Powell and Shan (2012) also study the importance of interval length and find that once the interval is larger than one year, the estimates are relatively consistent for all interval lengths.

these years as periods t and $t+1$ to simplify notation throughout the paper. We exclude individuals not working in period t from the sample since our empirical strategy relies on differences in labor earnings, and we do not observe an initial measure of labor earnings for non-workers. It is possible to extend our method to account for this specifically, though it requires modeling the non-workers separately to study entry into the workforce. Given that entry into the labor force by non-workers is a relatively rare event for our age group (only 6.5% of non-workers are working in the next period in our data), we do not have the power to study this group.

We define "retired" in our data by two criteria: (1) no individual labor earnings and (2) self-declared as "retired." One caveat is that the survey asks respondents about their current self-reported retirement status, while the labor earning and tax variables all relate to the previous calendar year. We do not view this as a limitation for our analysis, however, given that we are using the retirement variable as a more permanent indicator of leaving the labor force. Observing retirement in the following year is consistent with that interpretation.

We present summary statistics for our data in Table I. While each person in our sample is working in period t, we observe a relatively high probability of exit from employment as only 72% of men and 73% of women are working two years later. 16% of the sample is retired by the next period. It is also notable that the older population tends to experience relatively large year-to-year tax rate changes, as shown in Figure 1 which plots the 2-year change in marginal tax rates by age. These large changes are primarily due to own and spousal labor supply changes such as retirement.

4 Model and Empirical Strategy

In this section we discuss a basic theoretical framework for modeling intensive and extensive labor supply responses to income taxes. Our approach studies the different mechanisms through which the tax schedule can impact labor supply. We use this model to derive our empirical specifications.

4.1 Theoretical Framework

We consider a basic static framework where one individual maximizes utility that is a function of consumption and labor. The budget constraint includes labor income, non-labor income (assumed to be exogenous in this model) and tax liability which is a function of both labor earnings and non-labor income. The utility function also includes a parameter related to a cost of working and is similar in spirit to the model found in Eissa, Kleven, and Kreiner (2008). The individual solves the following maximization problem:

$$\max_{c,L} U(c,L) - \mathbf{1}(L>0)q \quad \text{s.t.} \quad c = L + y^o - T[L + y^o]$$

where c represents consumption, L is labor earnings ($U_L < 0$), y^o is non-labor income, and $z = L + y^o$ is total income. $T[z]$ is total tax liability given total income z and is non-linear in z. q represents a fixed cost of working and enters the utility function. The fixed cost of working is equal to zero for those that do not work and we assume $q > 0$.

If we assume an interior solution, then the first-order conditions imply

$$\frac{U_L}{U_c} = -(1-\tau),$$

$$c = L + y^o - T[L + y^o].$$

where τ represents the marginal tax rate ($T' = \tau$). The insight from these equations is that changes in labor earnings (conditional on working) are a function of changes in $1 - \tau$ (the marginal net-of-tax rate) and changes in $L + y^o - T[L + y^o]$ (after-tax income) due to shifts in $T[\cdot]$. Gruber and Saez (2002) note that the effect of the marginal net-of-tax rate (substitution effect) and the effect of after-tax income (income effect) can be separately identified empirically due to the non-linearities in the budget constraint.[12] Changes in the marginal tax-rate are the same for everyone on the same segment of the tax schedule, but changes in after-tax income vary depending on a person's distance from the kink in the budget constraint.

Figure 2 plots an illustrative case. For simplicity, we graph the nonlinear budget set created by a tax schedule with two tax brackets. After-tax income is an increasing, non-linear function of taxable income. We consider the case where the marginal tax rate in the top bracket is reduced between periods $t = 0$ and $t = 1$, while the tax rate in the lower tax bracket remains constant. Person A is located in the lower tax bracket, while persons B and C are in the top tax bracket. Comparing A and B, it is clear that the tax schedule change reduces the marginal tax rate for person B, while leaving the marginal tax rate for person A unaffected. Comparing B and C, we observe that while both individuals experience the same change in the marginal tax rate, they experience differential changes in after-tax income (labeled ΔATI). Thus, the marginal tax rate and after-tax income are separately identified due to the nonlinearities in the budget constraint.

Individuals may decide not to work and this decision is also related to the tax schedule. In the above equations, we can solve for interior solutions c^* and L^*. Then, we can compare the utility from working to the utility from not working. Consider an individual

[12] The budget constraint is non-linear because the tax schedule sets different marginal tax rates for distinct segments of total income.

that is indifferent between working and not working:

$$U(L^* + y^o - T[L^* + y^o], L^*) - q = U(y^o - T[y^o], 0).$$

For fixed preferences and L^*, we can see that labor force participation decisions are a function of after-tax income $L^* + y^o - T[L^* + y^o]$ relative to after-tax non-labor income $y^o - T[y^o]$ (i.e., the after-tax income of the individual if she chooses not to work). The difference between these two quantities is the additional income earned by the individual in after-tax dollars by participating in the labor force. Both of these terms depend on $T[\cdot]$. Consequently, the extensive margin substitution effect is defined by the value of $L^* + y^o - T[L^* + y^o]$ relative to $y^o - T[y^o]$, while the extensive margin income effect is defined by shifts in $y^o - T[y^o]$.

This result suggests that the nonlinearities can also be used to separately identify the effects of changes in after-tax labor income (the tax-based incentives to participate in the labor force) from after-tax income and the marginal net-of-tax rate, as illustrated in Figure 3. This insight will be used to estimate the extensive margin effect of taxes on labor supply. To illustrate, consider two different people who initially have identical total pre-tax income (marked C, as in Figure 2) but different levels of non-labor (NL) income (e.g., spousal earnings). Non-labor income for person 1 and 2 are represented by C_1^{NL} and C_2^{NL}, respectively. The additional after-tax income earned by person 1 due to working is represented by the vertical distance between C_1^{NL} and C. Suppose the tax rate decreases for the top tax bracket between periods $t = 0$ and $t = 1$, as before. Note that the pecuniary incentives to work (labeled $\Delta ATLI_{C1}$ and $\Delta ATLI_{C2}$) have increased more for person 1 than for person 2. Holding everything else constant, person C_1 earns an additional amount after taxes if she works relative to the amount she earns if she doesn't work following the tax cut. However, person 2 benefits from the tax cut regardless of whether or not she works. The benefits of working have increased for person 2 but have increased even more for person 1.

Consequently, we can find two people who experience the same change in the marginal tax rate and after-tax income, but experience different changes in the pecuniary incentives to working (i.e., after-tax labor income). We take advantage of the separate identification of the marginal tax rate, after-tax income, and after-tax labor income due to non-linearities in the budget constraint to estimate the intensive and extensive margin effects of income taxes.

4.2 Empirical Strategy

Our empirical strategy models and estimates the impact of taxes on both the intensive and extensive margins of labor supply for older workers, using the insights of the above theoretical framework. We discuss the intensive margin first, followed by the extensive margin.

4.2.1 Intensive Margin Effect

We begin by modeling intensive labor supply decisions. We use labor earnings as our measure of intensive labor supply.[13] Given that the labor supply literature has consistently found that men and women respond to labor market incentives in different ways, we perform all estimations separately by gender. Our specification models changes in labor earnings as a function of changes in the marginal net-of-tax rate (substitution effect) and changes in after-tax income (income effect). This equation is similar to the main specification used in

[13] We use labor earnings as the outcome of interest for several reasons. First, labor earnings are the product of a host of choices that may respond to tax incentives such as hours worked, amenity preferences, and effort. Thus, labor earnings is a useful summary metric that combines all of these components. Second, we are specifically interested in the potential ramifications of policies that alter older individuals' incentives to work and the subsequent impact on earnings as a means of supplementing or replacing Social Security benefits. Third, the tax code can and does tax labor income in a different way than it taxes other income. For drawing policy implications, it is important to understand how labor income responds to taxes independent of other sources of income. Finally, our model suggests that individuals respond to the additional income earned by participating in the labor force so we need to estimate labor earnings for each individual in our sample to construct this measure.

the elasticity of taxable income literature. Specifically, the intensive margin labor supply equation can be written as follows:

$$\ln L_{i,t+1} - \ln L_{it} = \alpha_t + X'_{it}\delta + \beta^I \left[\ln(1-\tau_{i,t+1}) - \ln(1-\tau_{it})\right] \\ +\theta^I \left[\ln\left(y_{it} - T_{t+1}(y_{it})\right) - \ln\left(y_{it} - T_t(y_{it})\right)\right] + \epsilon_{it} \quad (1)$$

where L is own-labor income, τ is the marginal tax rate, such that $\ln(1-\tau_{i,t+1}) - \ln(1-\tau_{it})$ represents the change in the log of the marginal net-of-tax rate for person i between periods t and $t+1$. y is total household income (including non-labor income) and $T(y)$ is the total tax liability for income y. $\ln\left(y_{it} - T_{t+1}(y_{it})\right) - \ln\left(y_{it} - T_t(y_{it})\right)$ is the change in the log of after-tax income due to tax burden shifts. X is a vector of covariates. We create cells based on age and education of individual i. There are 4 education categories (less than high school, high school graduate, some college, college graduate) and 5 age group categories (55-60, 61-64, 65-67, 68-70, 71+) for a total of 20 cells.[14] We include an indicator variable for each cell. We also include indicator variables based on spouse's age (under 55,[15] 55-60, 61-64, 65-67, 68-70, 71+) and year fixed effects which are allowed to have different effects based on initial marital status. We also control for flexible functions in initial (period t) adjusted gross income (AGI). Our instrumental variable strategy (described below) relies on the inclusion of a flexible function in initial AGI. We create 10 "bins" based on initial AGI and include dummy variables for each bin and a 10-piece spline as well. We also include controls for the log of initial own-labor earnings, the log of initial spousal earnings, and the log of initial household income.

We restrict estimation of equation 1 to individuals with observed labor earnings in period $t+1$ (i.e., employed individuals), which motivates our concerns about systematic

[14] The results are not meaningfully affected by the use of different age categorization.

[15] While our sample includes people 55+, a respondent's spouse may be younger.

selection (discussed in Section 4.3.2). The substitution and income effects are separately identified using legislative tax schedule changes, so that β^I can be interpreted as a compensated elasticity. We expect this parameter to be positive. We follow Powell and Shan (2012) when constructing the after-tax income variable, which is specified in a slightly different manner than the analogous variable in Gruber and Saez (2002). This is discussed in more detail in Appendix Section A.

4.2.2 Extensive Margin Effect

We also estimate extensive margin decisions for both the decision to work and retire. According to our theoretical model, an individual's decision to work is a function of their additional after-tax labor income from working: total after-tax income if the person works minus their total after-tax income (i.e., after-tax non-labor income) if the person does not work. We study the decision to work (or retire) in period $t+1$ for all individuals working in period t. We model the extensive margin in the following manner:

$$P\left(\text{Work}_{i,t+1}=1\right)=F\Bigg(\phi_t+X_{it}'\gamma+\beta^E\Big\{\ln\left[L_{i,t+1}+y^o_{i,t+1}-T_{t+1}(L_{i,t+1}+y^o_{i,t+1})\right]-\ln\left[y^o_{i,t+1}-T_{t+1}(y^o_{i,t+1})\right]\Big\} \tag{2}$$

$$+\theta^E\Big\{\ln\left(y^o_{it}-T_{t+1}(y^o_{it})\right)\Big\}+\nu_{it}\Bigg)$$

where $y^o_{i,t+1}$ is non-labor income. $T(L+y^o)$ represents the total tax liability if the individual works and earns labor income L. $T(y^o)$ is the individual's tax liability if they do not work. This specification models the probability of working (or retiring) in period $t+1$ as a function of the additional income that the individual receives if she works relative to the income she receives if she does not work. We use the difference in the log of after-tax income for working relative to after-tax income for not working as our measure of the pecuniary return to working. A person who works has log of annual after-tax income

$\ln [L + y^o - T(L + y^o)]$, while not working results in $\ln [y^o - T(y^o)]$. These are the variables suggested by our theoretical framework. We will refer to the difference between these two variables $\Big(\ln [L + y^o - T(L + y^o)] - \ln [y^o - T(y^o)] \Big)$ as "after-tax labor income." We also include the log of after-tax non-labor income so that we can interpret β^E as a compensated elasticity. We expect β^E to be positive for the probability of working and negative for the probability of retiring. As before, construction of our income effect variables are discussed further in the Appendix Section A. Note that $L_{i,t+1}$ and, consequently, $T_{t+1}(L_{i,t+1} + y^o_{i,t+1})$ are not observed for non-workers in period $t + 1$. We discuss how we address this issue in detail in the next section.

4.3 Identification Challenges

Equations (1) and (2) pose a few identification challenges. First, changes in tax rates and after-tax income are functions of changes in labor earnings and, therefore, OLS will not provide consistent estimates. In equation (2), individuals with higher L (and consequently, higher tax liabilities) may be more likely to work for reasons unrelated to after-tax earnings. Second, we do not observe $L_{i,t+1}$ for individuals that do not work in period $t + 1$. Thus, we do not observe $\left[\ln \left(L_{i,t+1} + y^o_{i,t+1} - T_{t+1}(L_{i,t+1} + y^o_{i,t+1})\right) - \ln \left(y^o_{i,t+1} - T_{t+1}(y^o_{i,t+1})\right)\right]$ in equation (2) for the extensive margin. Furthermore, we can only estimate the intensive margin equation (1) for a selected sample of individuals who participate in the labor force. In the sections that follow, we discuss how we address these endogeneity and selection issues.

4.3.1 Instruments

To address the mechanical relationship between earnings and taxes, we create a set of instruments to isolate plausibly exogenous variation in the tax variables. Our two structural equations include four tax-related variables: the marginal net-of-tax rate, after-tax income, after-tax labor income, and after-tax non-labor income. These are all potentially endogenous since taxes are a function of labor income and labor force participation. We implement an instrumental variables strategy that exploits independent variation in these tax-related variables derived from legislative tax schedule changes.

Specifically, we take advantage of changes in federal tax policy during our study period that changed tax-based incentives for reasons unrelated to individual changes in labor supply behavior. During our sample period, there were two key tax reforms: 1) the Economic Growth and Tax Relief Reconciliation Act (EGTRRA) of 2001, which reduced tax rates for each bracket with especially large changes for those with relatively low incomes; 2) the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) of 2003, which also reduced tax rates, primarily focusing on high income households. We also observe small tax rate changes in 2009 due to changes to the EITC (which affect a small part of our sample) and the Making Work Pay tax credit which reduced marginal tax rates by 6.2% at low incomes. We can observe these tax reforms in our data. Our empirical strategy will rely on the effects of these tax reforms for a fixed sample. To illustrate the variation generated by the tax reforms, we calculate the marginal tax rates for our entire sample in each year (holding household characteristics and real income constant) and graph the trend in the average simulated marginal tax rate in each year in Figure 4.

We employ an instrumental variables strategy similar in spirit to the one found in Gruber and Saez (2002). These instruments have become standard in the literature. This approach involves two steps: first, they calculate the marginal tax rate and tax liability for each person in period t based on household income, assets, and other characteristics using TAXSIM; second, holding real income constant (by inflating the nominal values) and all other variables constant, they calculate the individual tax rate and tax liability in period

$t+1$ applying the next period's tax schedule. These calculations provide the predicted change in the log of the marginal net-of-tax rate and the predicted change in the log of after-tax income which are used as instruments for the actual changes in each variable.

Although the legislative tax schedule changes themselves are unrelated to changes in labor supply behavior, one concern with this approach is that variation in the instruments is inherently related to cross-sectional variation in initial income, which may itself predict changes in labor outcomes. For example, given a federal legislative tax change which reduces marginal tax rates for higher income tax brackets relative to marginal tax rates for lower income tax brackets, the Gruber-Saez method compares changes in income for people with high initial incomes to people with low initial incomes. However, people with high initial incomes may have experienced different income changes relative to those with low incomes in the absence of policy changes due to mean reversion or differential secular trends. To address this concern, papers in the literature control for initial income, typically employing a flexible spline.[16] Even with a flexible spline, identification is still originating from variation in initial taxable income and the controls may not fully account for differential trends.

While our strategy is similar in spirit to the Gruber and Saez (2002) approach, we modify it to pay special attention to the potential biases arising from mean reversion and secular trends. Our contribution is to construct the instruments by predicting changes in the tax variables based on covariates instead of based on individual-specific initial income and characteristics. In particular, we force the instruments to vary based only on a specified function of initial taxable income, labor earnings, income, and household characteristics. Then we can control for this precise function of covariates in all of our analyses. In this way, we can break the link between cross-sectional variation in individuals' initial income and the tax instruments. While these covariates alone may not perfectly control for differential mean

[16]Gruber and Saez (2002) uses a 10-piece spline in initial taxable income.

reversion and trends, this is not a concern since our strategy ensures that no variation in the instruments is originating from initial income (beyond the variables that are controlled for in the intensive and extensive equations). Thus, the instruments are uncorrelated with secular trends that may independently predict changes in labor supply.

Our approach is similar to the simulated instrument strategy found in Currie and Gruber (1996a,b), where a common sample is used to generate predicted policy measures by simulating the policy effect for each observation and predicting the instruments based on covariates (e.g., state dummies in Currie and Gruber (1996b)). The regressions, then, include those same covariates (state dummies) and year fixed effects to isolate the effects of the policy changes. In the tax literature, the most similar empirical strategy in spirit is found in Gelber and Mitchell (2011), which predicts labor earnings for the entire sample based on covariates and then uses the tax code schedule in that year to generate variation.

Our method for constructing the instruments can be summarized by the following steps. We discuss construction of the predicted change in the log of the marginal net-of-tax rate here. The other instruments are generated using the same procedure. Note that an observation in our data includes the labor supply outcomes of the individual for the initial period t and the following period $t+1$.

1. Holding real income and household characteristics constant, we simulate the change in the log of the marginal net-of-tax rate for every observation in the sample assuming that they were initially subject to the year s tax code and subject to the $s+1$ tax code in the following period. For example, we take the entire sample and assign each observation to 1999. We calculate the change in the log of the marginal net-of-tax rate for that observation (holding household characteristics and real income constant) as if the observation had initial year 1999. We represent the simulated change by $\Delta \ln(1-\tau_{it}^{1999}) \equiv \ln(1-\tau_{i,t+1}^{2001}) - \ln(1-\tau_{it}^{1999})$, where τ_{it}^{s} represents the tax rate that

the observation would have faced under the year s tax schedule given the same real income and household characteristics. We repeat this step for initial years 2001, 2003, 2005, and 2007.

2. We regress each year-to-year change (e.g., $\Delta \ln(1 - \tau_{it}^{1999})$) on X_{it}, where X_{it} is the same vector as in the intensive margin and extensive margin equations, which includes measures of initial income and household characteristics. Let δ_{1999} represent the coefficients on X_{it} for the regression for initial year 1999. We estimate unique vectors of coefficients for each year-to-year change similarly (i.e., $\widehat{\delta}_{2001}, \widehat{\delta}_{2003}, \widehat{\delta}_{2005}, \widehat{\delta}_{2007}$). These estimated coefficients parameterize the relationship between initial characteristics and the predicted change in the log of the marginal net-of-tax rate in a flexible way.

3. Using these vectors of coefficients, we predict the change in log of marginal net-of-tax rate for each observation in the sample in each base year. In 1999, this would be $\Delta \ln\widehat{(1 - \tau_{it}^{1999})} = X_{it}'\widehat{\delta}_{1999}$.

4. We assign the predicted change in log of marginal net-of-tax rate based on t. Observations with initial year t are assigned $\Delta \widehat{\ln(1 - \tau_{it}^{t})}$:

$$\Delta \widehat{\ln(1 - \tau_{it})} = \sum_{s} \Delta \widehat{\ln(1 - \tau_{it}^{s})} \times \mathbf{1}(t = s) \tag{3}$$

In Step 2, it should be noted that the right-hand side X is identical regardless of which initial year is being simulated. In other words, the sample and covariates are held constant across regressions. Moreover, the inputs used to generate the left-hand side ($\Delta \ln(1 - \tau_{it}^{s})$) are also identical across years with the slight caveat that we adjust all income measures for inflation to hold real income constant. Consequently, the *only* reason that the left-hand side varies from one year to another is because the tax code has changed. As a result, $\widehat{\delta}_s$ also varies from one year to another only due to tax code changes.

The advantage of Step 2 is that we restrict the instruments to vary based on our function of covariates: X_{it}.[17] Identification originates solely from the interaction of X_{it} and the tax policy changes, and we can control precisely for X_{it}, accounting for the independent effects of initial income and characteristics on labor supply changes, and the tax policy changes (i.e., year fixed effects). To contrast, Gruber and Saez (2002) uses the interaction of AGI and the tax policy changes for identification, while controlling for a parametric function of AGI (and year fixed effects). Thus, some identification in Gruber and Saez (2002) originates from residual cross-sectional variation in initial AGI.

In the end, we construct four instruments using this method:

1. Predicted change in log of the marginal net-of-tax rate: $\widehat{\Delta \text{MTR}}_{it}$
2. Predicted change in log of after-tax income: $\widehat{\Delta \text{ATI}}_{it}$
3. Predicted log of after-tax labor income: $\widehat{\text{ATLI}}_{it}$
4. Predicted log of after-tax non-labor income: $\widehat{\text{ATNI}}_{it}$

The first and second instruments will be used for identification of equation (1). The third and fourth instruments will be used for identification of equation (2). Furthermore, the third instrument will be included as a determinant of selection into labor force participation in our selection equation, which we discuss below.[18] Given that our analysis is performed separately by gender, we generate all instruments separately by gender.

[17] Covariates were discussed in Section 4.2.1. The initial income measures included in X_{it} are important in terms of tracing out the tax variables. Since these exact same variables are included in all of our specifications, we are free to include more or less flexible functions. More flexible functions will better trace out the tax incentives faced by households while less flexible functions are computationally more tractable to include in our analyses. Our chosen parameterizations balance these two considerations.

[18] Technically, the fourth instrument is also excluded from equation (1), but given that after-tax labor income and after-tax non-labor income sum to after-tax income, we believe that only one of these variables is technically excluded. Our empirical strategy only requires one excluded variable.

4.3.2 Selection

Our second identification challenge is that we do not observe labor earnings for individuals who do not work. The concerns that arise from this are two-fold. First, the intensive margin labor supply equation is estimated for a selected sample of individuals who work in consecutive periods. This is a concern if, as the tax schedule becomes more generous, individuals with higher (psychic) costs to working enter the labor force. These individuals will likely work less on average and, consequently, we may associate generous tax schedules (higher marginal net-of-tax rates) with lower labor earnings, biasing against the predicted response. Second, in the extensive margin labor supply equation, we are unable to observe the after-tax labor income measure for those who do not work in period $t + 1$.

We address these two issues at the same time by jointly estimating the intensive and extensive margin labor supply equations. Combining the extensive and intensive margin equations is helpful for two reasons. First, the extensive margin equation provides a useful exclusion restriction to identify the selection mechanism in the intensive margin labor supply equation. To control for selection in the intensive margin equation, we need an instrument that affects labor force participation, but does not affect labor earnings conditional on participation. Fortunately, the extensive margin equation includes a variable that is excluded from the intensive margin equation: after-tax labor earnings. Thus, we can use predicted after-tax labor earnings as an exogenous shock to employment. This is a natural instrument for selection in the intensive margin equation.

It is important to again highlight that the predicted after-tax labor income variable is separately identified from the predicted changes in the marginal net-of-tax rate and the predicted changes in after-tax income due to the nonlinearities in the tax schedule. Thus, we use our predicted after-tax labor earnings as an instrument for selection while conditioning on the change in after-tax income and the change in the marginal net-of-tax rate. We find that this selection instrument has a strong relationship with labor force participation. The literature has typically relied on instruments such as number of children or preschool-aged children (e.g., Eissa and Hoynes (2004) and Eissa, Kleven, and Kreiner (2008)) with the assumption that people with children and people without children would have the same labor earnings if they worked. We introduce a new instrument for employment which may prove useful in other applications.

We use this selection instrument to estimate a probit model of labor force participation and construct the inverse Mills ratio following the standard Heckman approach. The inverse Mills ratio is then included as a control in the intensive margin equation to adjust for selection. Additionally, we use a semi-parametric approach to correct for selection which does not assume joint normality of the error terms. In this semi-parametric approach, selection into employment implies that

$$E\left[\epsilon_{it}|\widehat{\Delta\text{MTR}}_{it}, \widehat{\Delta\text{ATI}}_{it}, \widehat{\text{ATLI}}_{it}, X_{it}, \alpha_t, \text{Work}_{i,t+1} = 1\right] = \lambda(\mathbf{W}'_{it}\zeta) \tag{4}$$

where W includes our instruments for the intensive labor supply equation, the selection instrument, and all exogenous variables in equation (1). We do not assume any functional form for $\lambda(\cdot)$ and instead use a series approximation, as suggested in Newey (2009). We estimate the selection equation using the monotone rank estimator introduced in Cavanagh and Sherman (1998), which requires no distributional assumptions to obtain consistent estimates (up to scale).

Second, estimating the intensive and extensive equations together is helpful because the intensive labor supply equation provides consistent predictions of earnings for non-workers. We can use these predictions to estimate the extensive margin labor supply equation. Specifically, after we have estimated the intensive labor earnings equation (adjusting for selection), we predict earnings and calculate tax variables for each person in the sample, including those who do not have period $t+1$ labor earnings. We then use these predicted labor earnings, which generate the estimated return to working, to estimate the extensive margin equation.

The labor supply literature has previously considered methods for imputing earnings for non-workers for extensive margin equations of this form. Consistent imputation is important to arrive at unbiased coefficients. Given that we obtain consistent estimates of the parameters in the intensive margin equation, we can make consistent predictions of labor earnings for the entire sample, even those not working in period $t+1$. These predictions will allow us to compute after-tax labor earnings in the extensive margin equation for those who do not work in $t+1$.

4.4 Implementation

Our method proceeds in three steps. We describe the technical details in Appendix Section B. First, we estimate the selection equation and predict the selection adjustment term for the intensive labor supply sample. Second, we estimate the intensive labor supply equation using 2SLS while conditioning on the selection adjustment term. We use the estimates from this equation to predict labor earnings for the entire sample. We also estimate tax liabilities given these labor earnings. Third, using the estimated after-tax labor earnings variable, we estimate the extensive margin equation. Due to the use of a three-step estimation process, we bootstrap the entire process to generate standard errors. We use a clustered (by household) bootstrap procedure.

5 Results

We present our results in the order that the equations are estimated: selection equation, intensive margin equation, and extensive margin equation. For these last two equations, we include estimates with (1) no selection adjustment; (2) a Heckman selection adjustment method; (3) a semi-parametric selection adjustment method. In the extensive margin estimation, the type of selection adjustment refers to the method used to impute earnings (and the corresponding tax variables).

5.1 Selection Adjustment

In Table II, we present results for the selection equation. All exogenous variables are included in these regressions. Adjusting for selection in the intensive labor supply equation requires an excluded variable that is correlated with participation in the labor force but is unrelated to labor earnings. Technically, it is possible to identify purely off of distributional assumptions using the Heckman (1979) method and a probit regression. Even with an excluded variable, some of the identification will originate from distributional assumptions. The semi-parametric method that we employ, however, does require an excluded variable that predicts labor force participation. In this case, identification of the selection term originates solely from our selection instrument.

Column (1) includes the results from a probit regression of the effect of the excluded tax variable (predicted after-tax labor income) on labor force participation for women. Column (2) presents semi-parametric estimates of the same selection equation using the monotone rank estimator introduced in Cavanagh and Sherman (1998). The monotone rank estimator estimates the index without any distributional assumptions. These latter estimates are only identified up to scale and we normalize all of the coefficients so that the sum of the square of all coefficients is equal to 1. To aid comparison between columns (1) and (2), we normalize the probit estimates in the same manner. Columns (3) and (4) show the analogous results for men.

We observe few differences in the results across estimation methods. For women, we find that the selection instrument (predicted after-tax labor income) positively predicts labor force participation in the next period. This relationship is statistically significant and varies independently in relation to the marginal net-of-tax rate and after-tax income variables. The coefficients on these other tax variables are close to zero and statistically insignificant. The significant relationship between the selection instrument and the outcome variable is important since our method requires that we have a determinant of labor force participation that is excluded from the intensive margin equation.

In the corresponding estimates for men, we also find that the selection instrument is positively and statistically significantly associated with labor force participation. This relationship holds regardless of the estimation method that is used. The estimates also suggest that predicted increases in after-tax income are associated with a decreased likelihood of working. For both men and women, we have identified a variable which predicts labor force participation and is theoretically excluded from the intensive labor supply equation. We can use the predictions from these estimates in our intensive margin estimation to account for selection.

5.2 Intensive Margin

Due to the mechanical relationship between income and taxes, estimating our intensive margin equation requires the use of instrumental variables. Before proceeding to the 2SLS intensive margin estimates, we present evidence that our instruments are significantly related to the endogenous tax variables. Table III presents the first stage results for the intensive labor supply equation. We present partial F-statistics, which measure the independent relationship of the instruments with each endogenous variable. We find strong first-stage relationships for both women and men. Specifically, we find that predicted changes in the marginal net-of-tax rate are associated with changes in the actual marginal net-of-tax rates experienced by the individuals at approximately a one-to-one rate. We obtain similar estimates for changes in after-tax income. The partial F-statistic for the marginal net-of-tax rate variable is 99.92 for women and 66.96 for men. The partial F-statistic for the after-tax income variable is 1278.68 for women and 2013.29 for men. Thus, the first-stage relationships are suitably strong by conventional cut-offs (Staiger and Stock (1997)).

Table IV presents the results from 2SLS estimation of the intensive labor supply equations. We interpret the coefficients on the marginal net-of-tax rate as compensated elasticities since we separately account for income effects. For women, we estimate an elasticity of 0.332 when no selection adjustment is made (Column (1)), 0.333 when a Heckman adjustment is made (Column (2)), and 0.305 when the semi-parametric adjustment is made (Column (3)). This last estimate implies that a 10% increase in the marginal net-of-tax rate increases labor earnings by 3.1%. For men, we estimate elasticities of 0.038, 0.190, and 0.230, respectively. While these estimates are the expected sign, they are not statistically distinguishable from zero. The standard errors in this table are rather large, likely due to the relatively high variance of labor earnings for this population. While our estimates do not allow us to reject that older workers do not respond to changes in taxes on the intensive margin, we are also unable to rule out rather large elasticities. The point estimates are similar to those found in the elasticity of taxable income literature which does not select on older ages. For example, Giertz (2007) estimates elasticities of 0.40 and 0.26 (depending on the years of the sample), Auten, Carroll, and Gee (2008) estimate an elasticity of 0.4, and Singleton (2011) estimates an elasticity of 0.2-0.3. Our income effect estimates are also generally the expected sign though these are also statistically insignificant due to large standard errors.

Adjusting for sample selection does not appear to change the estimates in a meaningful way. However, accounting for possible selection bias has advantages in our empirical approach beyond estimating consistent coefficients for the marginal net-of-tax rate and after-tax income variables. The selection adjustment allows for consistent estimation of *all* the parameters in the intensive margin equation. This is critical because we use the results from estimating the intensive margin equation to generate predicted labor earnings, which we then use in the extensive margin equation. These predicted earnings are a function of the age-education interactions, spousal age dummies, and other covariates included in the specification. While we find that selection does not bias the parameters reported in Table IV, it is possible that selection may bias other included variables, and consequently, the labor earnings predictions that are generated from this equation. Our selection corrections address this concern.

5.3 Extensive Margin

After using the intensive margin equation to predict each person's labor earnings in period $t+1$ for workers and non-workers, we then calculate the additional taxes that the individual would pay (had they worked) in that period. The main endogenous variable in our extensive margin equation is the additional after-tax earnings due to working. We also include after-tax non-labor income, which is also considered endogenous. Our instruments are predicted after-tax labor income and predicted after-tax non-labor income. We present the results for the extensive margin labor supply equation in Table V using an IV-Probit regression. We present average marginal effects for the sample. We find large effects on working for both men and women and these effects are statistically significant. The results are robust across the different selection methods. We estimate that a 10% increase in after-tax labor income increases the probability of labor force participation by 5.5 percentage points for women in our preferred specification (semi-parametric). We obtain similar estimates for men: a 10% increase in after-tax labor income increases the probability of labor force participation by 4.0 percentage points. The Appendix includes 2SLS results using a linear probability model (see Appendix Table C.1). The results are similar.

Among individuals ages 55 to 75, the probability of working in the next period, conditional on working in the current period, is 0.734 for women and 0.723 for men. We use these probabilities to construct elasticities from the estimates from Table V. The implied elasticities are 0.755 for women and 0.548 for men.[19] These elasticities refer to the labor force participation responsiveness with respect to changes in after-tax labor income. Ultimately, we are interested in the impacts of tax rate changes, not changes in after-tax labor earnings, on labor force outcomes. Our simulation results in Section 5.4 will facilitate this interpretation.

We compare these elasticities to related estimates found in the literature, with the caveat that these comparisons are difficult given the use of different methods and the use of different functional forms for the extensive margin tax variable.[20] We refer to Eissa and Hoynes (2004) which studies the effect of the EITC on the labor force participation of married couples ages 25-54. They estimate an elasticity of 0.267 for women and 0.032 for men. Compared to their paper, we find much larger estimates for both men and women. Gelber and Mitchell (2011) estimate a participation elasticity of 0.41, while Eissa, Kleven, and Kreiner (2008) summarize the literature on the effects of taxes on non-elderly female household heads as finding a central value of 0.7. Given the noted successes of the EITC, these results suggest

[19] We calculate these elasticities using $\widehat{\beta^E} \times \frac{1}{P(work)}$.

[20] Many papers in the tax literature assume that labor force participation decisions are based on the average tax rate. Our model illustrates that the after-tax labor income is theoretically justified, though the average tax rate may be highly-correlated with our variable.

meaningful scope for impacting labor force participation of older individuals through the tax code.

Finally, we repeat the above extensive margin analysis but focus on retirement as the outcome variable. We use retirement as a measure of a more permanent labor force participation effect. These estimates are presented in Table VI. Analogous linear probability model results are found in Appendix Table C.2. We find strong effects on retirement decisions for women. Our estimates imply that a 10% increase in after-tax labor income reduces the probability of retirement by 2.9 percentage points. Consequently, over 50% of the tax effect on increasing the probability of working in Table V is driven by a reduction in retirement. For men, our point estimates suggest that a 10% increase in the pecuniary return to working decreases the probability of retirement by 1.4 percentage points. This result implies that 36% of the labor force participation effect shown in Table V can be attributed to retirement. Overall, we find evidence that changes in the tax code may have more permanent effects on the labor supply of older workers.

5.4 Policy Simulations

The key finding in our analysis is that labor force participation is highly responsive to the additional taxes that older individuals would have to pay if they worked. In this section, we simulate the labor force participation ramifications of two policy experiments: 1) eliminating the employee portion of the payroll tax at age 65; 2) expanding EITC to individuals ages 65 and over and eliminating the dependent requirement at these ages. We use the predicted probabilities from the semi-parametric estimates (Table V presented the average marginal effects for this analysis) and estimate the average change in the probability of working under these two tax policies. Since both of these policies increase the generosity of the tax code at specific ages, implementation of these polices may also have dynamic effects if we believe that individuals will shift their labor supply to periods in the life-cycle where they would earn more given the same amount of effort. Given the tax code changes that we exploit, we cannot study this possibility without imposing more restrictive assumptions. Instead, we note that the following estimates are lower bounds if individuals would delay some of their labor supply until the period when they face lower taxes. We also do not quantify the corresponding labor supply reductions at younger ages.

In our first policy experiment, we consider the elimination of the employee portion of FICA taxes at age 65.[21] We assume that an equivalent lump sum tax is levied on each person such that we can ignore income effects. For each person, we predict (1) the probability of working under period $t+1$ tax rules and (2) the probability of working under "counterfactual" tax rules, substituting in

$$\ln\left[L_{i,t+1} + y^o_{i,t+1} - T^c_{t+1}(L_{i,t+1} + y^o_{i,t+1})\right] - \ln\left[y^o_{i,t+1} - T^c_{t+1}(y^o_{i,t+1})\right],$$

where T^c_{t+1} represents the counterfactual tax burden in period $t+1$ given the elimination of the employee portion of FICA taxes. The difference in these probabilities gives us the effect of this policy on labor supply behavior. Table VII shows the results of this simulation.

In our baseline sample, 26.6% of working women and 27.7% of working men will not earn positive wages two years later. Elimination of the employee FICA taxes would reduce this percentage by 1.8 percentage points for women and 1.6 percentage points for men. This is a 6.8% decrease in the probability of not working for women and a 5.8% decrease for men. We further estimate that there would be a 1.0 percentage point drop in retirement for women, representing a 6.2% decrease from baseline. The probability of retirement for men would decrease by 0.6 percentage points, a 3.8% decrease.

[21] Laitner and Silverman (2012) eliminates both the employee and employer portions.

Our second policy experiment is similar to the one suggested in Schimmel and Stapleton (2010). This policy expands the EITC to the 65+ population while eliminating the requirement of dependents. We implement this policy on our 65+ sample, again assuming that an equal lump sum tax is levied on individuals. In our analysis, we apply the EITC schedule for 2009, the latest year in our sample.[22] In 2009, the credit was phased-in at a rate of 45% up to $12,570 of earned income for a maximum benefit of $5,657. The benefit remained constant between $12,570 to $16,450. At $16,450 of earnings, the credit was phased out at a rate of 21.06%, implying that no credit was received at an income of $43,279 or higher. Table VIII presents the results from this simulation. We estimate that this policy would decrease the probability that a female worker leaves the labor force by 6.0 percentage points. The probability that a male worker would leave the labor force would be reduced by 3.1 percentage points. These represent reductions of 22.6% and 11.2% from baseline, respectively. We also again find proportional reductions in retirement probabilities for both women and men. The effects of the EITC on delaying retirement and exit from working are much larger relative to the payroll tax reform. Intuitively, the EITC expansion is better-targeted to increase labor force participation since it has large effects on the pecuniary returns to work at low levels of income. The payroll tax reform also increases the returns to labor force participation but the proportional increase in after-tax labor earnings is much smaller near the Social Security maximum taxable earnings threshold than at lower levels of earnings.

In summary, we find that the two policies would have significant effects on labor force participation with larger labor force participation consequences for the EITC expansion. We also compare the tax losses associated with each policy (ignoring the implied lump sum taxes imposed in each case). Our calculation for the estimated per-person tax loss uses the

[22] We use the most generous benefit schedule available in 2009 which was the schedule for individuals with three children.

calculated tax losses for each person minus the additional taxes collected because of the increased labor force participation.[23] We estimate that, on average, women in our sample would pay $2,082 less in taxes under the payroll tax reform and $2,481 less due to the EITC expansion per year. Men would pay $1,585 less in taxes under the payroll tax reform and $1,818 less under the EITC expansion policy.

The retirement changes are especially interesting because they suggest that tax incentives can have dynamic effects on labor supply by causing older workers to drop out of the labor force in a more permanent manner. Understanding the permanence of these behavioral responses will be studied in future research.

5.5 Robustness Checks

In this section, we study the robustness of our results to a series of tests. For each test, we repeat our entire three-step procedure, but we only present a few select results. We use the semi-parametric selection adjustment method as our preferred specification in all cases. The robustness results are reported in Table IX. The first row shows the intensive margin results for the marginal net-of-tax rate variable only (corresponding to the marginal net-of-tax rate estimates in Table IV). The second row presents the extensive margin elasticity (corresponding to the estimates in Table V). The third row shows the results from the elimination of the employee portion of the payroll tax simulation and the final row shows the results from the EITC expansion simulation.

First, in columns 1 and 2 of Panel A, we repeat our main findings. Second, in columns 3 and 4 of Panel A, we replicate the analysis excluding 2009 data (using the 1999-2007 sample only). These results check the robustness of our results to excluding the period of the Great Recession. The Great Recession impacted labor supply decisions and differential

[23]These additional collected taxes including the employer portion of the FICA taxes.

secular trends during that time period may confound our estimates. Our extensive margin and policy simulation estimates are slightly larger when we exclude 2009 but, overall, the results are generally similar. The robustness of our results to the exclusion of 2009 provides evidence that our empirical strategy adequately accounts for differential trends.

Third, we report results in columns 5 and 6 of Panel A using a 5-piece spline of initial individual labor earnings as a control.[24] Our empirical strategy allows the instruments to vary based on initial labor earnings and we also control for this exact variable. This technique should reduce concerns of mean reversion or trends biasing our results. When we control for a more flexible function of initial own-labor earnings, our results are similar to the main results reported earlier in the paper. These results suggest that differential trends based on initial labor earnings are not driving our results. This supports the notion that our identification strategy is robust to wage trends and mean reversion concerns.

Fourth, we allow the effects of initial income to vary by year by interacting initial labor earnings and initial AGI with year dummies. This test accounts for the possibility that mean reversion effects or trends vary by year. We present these results in columns 7 and 8 of Panel A. We find little evidence that year-specific trends are important in explaining the results. The results are very similar to our main estimates, again suggesting that our empirical strategy accounts for trends and mean reversion concerns.

Fifth, in columns 1 and 2 of Panel B, we present results using nonlinear least squares (Poisson regression) to estimate the intensive margin equation. In our main specification, we used a log-linear form both because it is standard in the literature and because the techniques used to generate the constant term when a semi-parametric selection adjustment term is included are well-studied. However, there are two advantages to using Poisson regression. First, Silva and Tenreyro (2006) show that Poisson regression allows for a more

[24] More flexible splines also produce similar results.

flexible structure on the error term where a log-linear form assumes that the error term is multiplicative. Second, when predicting labor earnings for each person in our sample after estimation of equation (1), there are known problems with taking the exponential of the expectation of a log. Instead of estimating and predicting the log of labor earnings and then taking the exponential of this prediction, we can model labor earnings directly as an exponential of the explanatory variables. We then estimate this specification using IV-Poisson and predict labor earnings (not the log of labor earnings). The instruments are the same as the ones used for our main specifications.[25] The estimates from the Poisson regression are very similar to those using OLS, suggesting that use of the log-linear specification is not biasing our results. We find slightly larger effects for the payroll tax reform and slightly smaller results for the EITC expansion.

Sixth, our instrumental variable strategy involved running the entire sample through the tax code for each year in the data. Alternatively, we could have only used observations with initial year 1999 to generate the instruments. We replicate our instrumental variable strategy using the 1999 sample only to generate the instruments. We report the results in columns 3 and 4 of Panel B. We find that this alternative instrument construction does not change the results.[26]

Finally, one may also be concerned that our intensive margin equation does not fully capture all of the dimensions of intensive margin labor supply decisions, such as transitions to part-time work. We discuss this concern in detail in the next section.

[25]After estimating the intensive margin equation, we must estimate the constant. In our main specifications, we used the technique suggested in Heckman (1990). We modify this technique here to account for the change in the functional form of the specification. Our extension margin estimation, then, proceeds as before.

[26]We also can repeat the analysis reported in columns 3 and 4 of Panel B while dropping the 1999 sample from the estimation of the intensive and extensive effects. In other words, we can generate the instrument using only the 1999 sample but then exclude that sample from the three-step estimation process. We obtain similar estimates. For example, we estimate that the EITC expansion would decrease labor force exit probabilities by 0.025 for men and 0.058 for women, both significant at the 5% level.

5.5.1 Other Intensive Margins of Labor Supply

In theory, we could explicitly model part-time work (or partial retirement) and include an additional equation in our empirical model with this outcome variable. We would then create an equivalent instrument for the pecuniary incentives to work part-time (versus full-time) and predict transitions between full-time and part-time work. Unfortunately, this idea is not possible to implement in practice given that we observe relatively few such transitions from full-time to part-time work in our data[27] and the additional burden of identifying an additional equation. Instead, we will show that our model of intensive labor supply decisions uses tax variables that adequately explain the observed variation in labor earnings, even large changes due to transitions to part-time work.

It is possible that there are additional margins that our intensive and extensive equations do not capture. Workers may make intensive labor supply decisions which depend on income taxes but cannot be summarized by the marginal net-of-tax rate and after-tax income alone. For example, one might be concerned that decisions to transition into part-time work are not based purely on the marginal net-of-tax rate, but rather the reduction in after-tax labor income from transitioning from full-time to part-time work. This possibility is not necessarily problematic if changes in the tax-driven incentives on these omitted margins are orthogonal to changes in the budget constraint traced out by the included variables.

However, these discrete labor supply transitions are only problematic for estimating the intensive margin if they are: (a) tax-driven and (b) not adequately explained by the included tax variables in our main specification. We test for this in a few different ways. In Columns 5 and 6 of Panel B in Table IX, we present results where we "trim" the outcome variable in the intensive margin equation. This trimming eliminates large changes in labor earnings (i.e., full- to part-time transitions) to ensure that labor decisions resulting in large

[27]We observe 695 such transitions for women and 580 for men over the ten year period.

changes in labor earnings are not driving our results. We redefine our outcome variable using $\tilde{L}_{i,t+1} = \min\left[\max\left(L_{i,t+1}, 0.75L_{it}\right), 1.25L_{it}\right]$. In words, we reassign labor earnings representing large decreases to 75% of initial labor earnings, and we reassign large increases to 125% of initial labor earnings. The results in Table IX suggest that large changes in labor earnings are not driving our results. The tax variables used in our main specification appear to adequately explain the tax-based incentives that impact this population's behavior including both small and large changes in labor earnings.

Second, we can study the relationship between our instruments (the predicted change in the marginal-net-of tax-rate and predicted change in after-tax income) and part-time work directly. Specifically, we test whether our instruments predict part-time status. While it would not be surprising to find an effect since transitions into part-time work may depend on the marginal net-of-tax rate, the absence of a relationship would suggest that our tax variables are not systematically correlated with other tax-driven intensive labor supply decisions. We present the results of this test in Table X. We find no statistically significant relationships and, in fact, the signs of the coefficients on both variables are not consistent within the male and female samples, further suggesting that there is no systematic relationship.

Intensive margin decisions that are not captured by the marginal net-of-tax rate and after-tax income do not appear to be driving our final results. While we may believe that labor decisions are impacted by taxes in ways other than the marginal tax rate and tax liability, our contribution to the literature is modeling a crucial missing component in much of the literature - the tax-based incentive to participate in the labor force. Our empirical analysis suggests that our two equations are useful for understanding a rich set of labor outcomes related to the tax code.

6 Conclusion

This paper models both the intensive and extensive margins of labor supply, using each margin to enable more accurate and consistent estimation of the other. We model the intensive labor supply as a function of the marginal net-of-tax rate and after-tax income. Extensive labor supply is modeled as a function of the monetary benefit of working as measured by after-tax labor earnings. Both of these equations are difficult to estimate even with appropriate instrumental variables. The extensive labor supply equation, however, provides a natural exclusion restriction to account for selection in the intensive labor supply equation. This instrument is, to our knowledge, new to the labor supply literature, which has consistently suggested that selection instruments meeting the required conditions are difficult to find. Moreover, the intensive labor supply equation provides a means of imputing a crucial variable in the extensive margin equation (earnings for individuals who do not work), allowing us to generate consistent estimates for that equation as well.

We find statistically significant and economically meaningful effects of taxes on labor force participation for older workers. These estimates are similar or larger in magnitude than estimates found in the literature on extensive margin effects for the younger population, ages 25-54. These findings suggest scope for extending the working lives of older workers through the tax code. We also find evidence that men and women retire in response to higher taxes, implying the possibility that older workers exit the labor force more permanently when taxes increase. Since the prior labor supply and tax literatures rarely study the older segment of the population, frequently excluding them from analysis, this paper fills a large gap in these literatures and provides important estimates about the potential incentives in the tax code. We predict that age-specific tax reductions would cause this population to remain in the labor force longer and delay retirement.

Finally, we simulate the effects of two possible tax-based reforms. First, we estimate that eliminating the employee portion of the payroll tax would decrease the percentage of working women that leave the labor force by 6.8% and the percentage of working men by 5.8%. Second, we simulate effects of an EITC expansion to older ages and estimate that this reform would increase labor force participation of older female workers by 22.6% and the participation of older male workers by 11.2%.

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Appendix

A Income Effect

The Gruber and Saez (2002) after-tax income variable is $\ln(y_{i,t+1} - T_{t+1}(y_{i,t+1})) - \ln(y_{it} - T_t(y_{it}))$ and the paper models changes in taxable income as a function of this variable. However, this structural relationship may be problematic. Households respond to shifts in their budget constraints, but the Gruber and Saez (2002) variable assumes that they are responding to their final after-tax income, which includes the response to the budget constraint shift and changes in the marginal tax rate. Instrumental variable techniques do not solve this problem. This point is discussed in Powell and Shan (2012). An example can help make this point clearer. Imagine an individual with income $\tilde{y}$ in period 1 and no tax liability. The tax code changes such that this person is given a lump sum equal to $\tilde{y}$ in period 2. In response, the person changes behavior and earns income equal to 0. This is a strong income effect (i.e., income targeting) resulting from the outward budget constraint shift. However, the Gruber-Saez specification models the change in earnings $(-\tilde{y})$ as a function of the final change in after-tax income, which is 0. This is because using actual after-tax income changes includes the response to the tax change as well. The variable capturing the income effect should not include this endogenous response, only the budget constraint shift.

We include an after-tax income term because our shocks to the marginal net-of-tax rate also shock the individual's budget constraint. Our after-tax income term is the expected change in after-tax income given legislative changes in the tax schedule only. We hold everything constant and estimate the budget constraint shift due only to these changes. This separates the substitution and income effects as before, and we interpret our estimates as compensated elasticities.

We expect the coefficient on our income variable to be negative in the intensive labor supply equation. On the extensive margin, we follow a similar technique. Our endogenous variable uses initial non-labor income with shifts due to legislative tax schedule changes.

B Implementation Details

We explain the more technical details of the empirical strategy here. We describe each step in the order that it is estimated.

B.1 Step 1:

In the first step, we model the selection mechanism. When we report estimates that do not account for selection, this step is skipped. We must include all of the instruments used in the intensive labor supply equation. In the end, we estimate

$$P\left(\text{Work}_{i,t+1} = 1\right) = F\Big(\phi_t + X_{it}'\gamma + \beta_1 \widehat{\Delta\text{MTR}}_{it} + \beta_2 \widehat{\Delta\text{ATI}}_{it} + \beta_3 \widehat{\text{ATLI}_{it}}), \eta\Big) \quad (5)$$

The predictions provided by equation (5) are used as selection adjustments for the intensive equation. We do this in two different ways. First, we assume that $F(\cdot) = \Phi(\cdot)$, estimate equation (5) using a probit regression, and form an inverse Mills ratio as discussed in Heckman (1979). This method is frequently used in the literature.

Second, we use a monotone rank estimator introduced in Cavanagh and Sherman (1998). This estimator does not estimate $F(\cdot)$ but provides $\sqrt{n}$-consistent estimates up to scale of the coefficients in the argument of the function. We then predict the index function, which we denote as $W_{it}'\hat{\zeta}$. The selection correction term is a function of this index and we follow the method of Newey (2009) by approximating this term with a spline using

$W_{it}'\hat{\zeta}$.[28] The advantage of this approach is that the maximum rank estimator requires no distributional assumptions to obtain consistent $\hat{\zeta}$.

We coded the monotone rank estimator, generated initial values through a probit regression, and maximized the objective function using an MCMC optimization algorithm (see Chernozhukov and Hong (2003)).[29] Standard errors are generated using a clustered bootstrap.[30]

B.2 Step 2:

The second step estimates the intensive labor supply equation. Because of selection, we estimate the following:

$$\begin{aligned} \ln L_{i,t+1} - \ln L_{it} &= \alpha_t + X_{it}'\delta + \beta^I \left[\ln(1-\tau_{i,t+1}) - \ln(1-\tau_{it})\right] \\ &+\theta^I \left[\ln\left(y_{it} - T_{t+1}(y_{it})\right) - \ln\left(y_{it} - T_t(y_{it})\right)\right] + \lambda(W_{it}'\hat{\zeta}) + \mu_{it} \end{aligned} \tag{6}$$

In practice, we use an inverse Mills ratio or a 5-piece spline in $W_{it}'\hat{\zeta}$. We use $\widehat{\Delta \text{MTR}}_{it}$ and $\widehat{\Delta \text{ATI}}_{it}$ as instruments.

We bootstrap Steps 1 and 2 to account for the inclusion of an estimated term in equation (6). Since each household may be included multiple times in our data, we use a clustered bootstrap.

We should highlight that 2SLS includes the selection adjustment terms in the first stage as well. This has practical importance in our strategy. Notice that for individuals not working, we do not observe the change in their marginal net-of-tax rate if they had actually

[28]Newey (2009) recommends the use of a spline over a power series.
[29]Similar results are found using a Nelder-Mead optimization algorithm.
[30]Subbotin (2007) discusses properties of bootstrapping rank regression estimates.

worked. We predict this variable from the first-stage regression in the same way that we will predict labor earnings for period $t+1$.

We use 2SLS to obtain consistent estimates. Once we have consistent estimates for equation (6), we can predict $\ln L_{i,t+1} - \ln L_{it}$ for our entire sample. This includes people who did not work in period $t+1$. However, it is important to note that when using the Newey (2009) method, the constant term is not separately identified from the selection correction term. A method to estimate the constant term was introduced in Heckman (1990). Schafgans and Zinde-Walsh (2002) discuss consistency and asymptotically normality of this estimator. We implement this estimator to derive the constant term.

We predict the change in earnings for the entire sample using the estimated coefficients in equation (6), the estimated constant term, and the imputed change in $\ln(1-\tau_{i,t+1}) - \ln(1-\tau_{it})$. In other words, we have consistent predictions of the tax variables and the coefficients to predict $\ln L_{i,t+1} - \ln L_{it}$ for everyone in our sample. We use this to predict Ł$_{i,t+1}$ using

$$\widehat{L}_{i,t+1} = \exp(\ln L_{it} + \overbrace{\ln L_{i,t+1} - \ln L_{it}}^{\text{Predicted}}). \tag{7}$$

B.3 Step 3:

Once we have $\widehat{L}_{i,t+1}$, we can calculate $T\widehat{(y^o + \hat{L})}$ using NBER's TAXSIM program. Then, we estimate

$$P\left(\text{Work}_{i,t+1} = 1\right) = F\Big(\phi_t + X_{it}'\gamma + \beta^E \Big[\ln\Big(y^o_{i,t+1} + \widehat{L_{i,t+1}} - T\widehat{(y^o_{i,t+1} + \widehat{L}_{i,t+1})}\Big) - \ln\big(y^o_{i,t+1} - T_{t+1}(y^o_{i,t+1})\big)\Big]$$
$$+\theta^E\left[\ln\left(y^o_{it} - T_{t+1}(y^o_{it})\right)\right] + \nu_{i,t+1}\Big)$$

We estimate this equation using the IV-Probit technique introduced in Rivers and

Vuong (1988) (referred to as two-stage conditional maximum likelihood (2SCML) in the paper) with instruments

$$\widehat{\text{ATLI}}_{it} \quad \text{and} \quad \widehat{\text{ATNI}}_{it}$$

2SLS results provide similar results and are provided in Appendix Section C. For inference, we use a clustered bootstrap in which all three steps are simultaneously bootstrapped.

C Appendix Tables

Table C.1: Extensive Labor Supply Equation (Employment), 2SLS

Dependent Variable:	I(Employed)					
	Women			**Men**		
Selection Adjustment:	None	Heckman	Semi-Parametric	None	Heckman	Semi-Parametric
	(1)	(2)	(3)	(4)	(5)	(6)
ln(After-Tax Labor Income)	0.527***	0.527***	0.521***	0.365**	0.356**	0.360**
	(0.121)	(0.145)	(0.118)	(0.147)	(0.140)	(0.142)
Observations	9,357	9,357	9,357	8,517	8,517	8,517

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income. ln(After-Tax Non-Labor Income) also included and instrumented.

Table C.2: Extensive Labor Supply Equation (Retirement), 2SLS

Dependent Variable:	I(Retirement)					
	Women			**Men**		
Selection Adjustment:	None	Heckman	Semi-Parametric	None	Heckman	Semi-Parametric
	(1)	(2)	(3)	(4)	(5)	(6)
ln(After-Tax Labor Income)	-0.294***	-0.294***	-0.291***	-0.139**	-0.136**	-0.137**
	(0.072)	(0.081)	(0.069)	(0.063)	(0.061)	(0.063)
Observations	9,357	9,357	9,357	8,517	8,517	8,517

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income. ln(After-Tax Non-Labor Income) also included and instrumented.

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Tables

Table I: Descriptive Statistics

	Men	Women
Demographics		
Age	62.0	61.7
Less than HS	15.6%	13.1%
HS Grad	32.6%	39.0%
Some College	21.2%	25.7%
College Grad	30.6%	22.2%
Labor Outcomes		
Personal Labor Earnings	$43,346.47	$25,097.61
Spousal Labor Earnings	$14,278.31	$13,465.06
Work in Next Period	72.3%	73.4%
Wages in Next Period if Work	$49,875.79	$30,850.33
Retired in Next Period	15.6%	16.1%
Total Household Income	$109,541.40	$80,315.34
Tax Variables		
Marginal Tax Rate	27.8	26.0
Change in MTR	-3.5	-3.5
N	8,517	9,357

Notes: All dollar values expressed in 2009 dollars.

Table II: Selection Equation, Reduced Form

Dependent Variable:	I(Work)			
	Women		Men	
	(1)	(2)	(3)	(4)
Predicted Δ in ln(1 − Marginal Tax Rate)	0.001	-0.001	-0.004	-0.006
	(0.007)	(0.010)	(0.020)	(0.027)
Predicted Δ in ln(After-Tax Income)	-0.013	-0.012	-0.099*	-0.097*
	(0.025)	(0.025)	(0.056)	(0.057)
Predicted Δ in ln(After-Tax Labor Income)	0.026***	0.025***	0.033***	0.031***
	(0.007)	(0.007)	(0.011)	(0.011)
Probit	X		X	
Monotone Rank		X		X
Observations	9,357	9,357	8,517	8,517

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. Coefficients are scaled so that sum of the square of the coefficients is equal to 1. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income.

Table III: Intensive Labor Supply Equation, First Stage

Dependent Variable:	$\Delta \ln$(1-MTR)	$\Delta \ln$(After-Tax Income)	$\Delta \ln$(1-MTR)	$\Delta \ln$(After-Tax Income)
Predicted $\Delta \ln$(1-MTR)	1.126***	0.010	0.945***	0.005
	(0.112)	(0.008)	(0.115)	(0.006)
Predicted $\Delta \ln$(After-Tax Income)	-0.165	1.001***	-0.198	0.954***
	(0.345)	(0.028)	(0.289)	(0.021)
Partial F-Statistic	99.92	1278.68	66.96	2013.29
Sample	Women	Women	Men	Men
N	6,867	6,867	6,154	6,154

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses adjusted for clustering at household-level. Other variables included: year dummies interacted with marital status; interactions based on age group $\times$ education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income.

Table IV: Intensive Labor Supply Equation, 2SLS

Dependent Variable:	ln(Labor Income)					
	Women			**Men**		
Selection Adjustment:	None	Heckman	Semi-Parametric	None	Heckman	Semi-Parametric
	(1)	(2)	(3)	(4)	(5)	(6)
Δ ln(1-MTR)	0.332	0.333	0.305	0.038	0.190	0.230
	(0.711)	(0.723)	(0.725)	(0.702)	(0.765)	(0.821)
Δ ln(After-Tax Income)	-2.683	-2.684	-2.644	-1.314	-0.148	-0.182
	(2.243)	(2.245)	(2.267)	(2.374)	(2.448)	(2.478)
Observations	6,867	6,867	6,867	6,154	6,154	6,154

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income.

Table V: Extensive Labor Supply Equation (Working), IV-Probit

Dependent Variable:	I(Work)					
	Women			**Men**		
Selection Adjustment:	None	Heckman	Semi-Parametric	None	Heckman	Semi-Parametric
	(1)	(2)	(3)	(4)	(5)	(6)
ln(After-Tax Labor Income)	0.560***	0.560***	0.554***	0.402**	0.392**	0.396***
	(0.175)	(0.139)	(0.123)	(0.160)	(0.154)	(0.152)
Observations	9,357	9,357	9,357	8,517	8,517	8,517

Notes: Significance Levels: *10%, **5%, ***1%. Average marginal effects for sample reported. Standard errors in parentheses estimated using clustered (by household) bootstrap. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income. ln(After-Tax Non-Labor Income) also included and instrumented.

Table VI: Extensive Labor Supply Equation (Retirement), IV-Probit

Dependent Variable:	I(Retirement)					
	Women			**Men**		
Selection Adjustment:	None	Heckman	Semi-Parametric	None	Heckman	Semi-Parametric
	(1)	(2)	(3)	(4)	(5)	(6)
ln(After-Tax Labor Income)	-0.297***	-0.300***	-0.293***	-0.145**	-0.141	-0.143**
	(0.078)	(0.079)	(0.070)	(0.072)	(0.134)	(0.063)
Observations	9,357	9,357	9,357	8,517	8,517	8,517

Notes: Significance Levels: *10%, **5%, ***1%. Average marginal effects for sample reported. Standard errors in parentheses estimated using clustered (by household) bootstrap. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income. ln(After-Tax Non-Labor Income) also included and instrumented.

Table VII: Effect of Eliminating Employee Portion of Payroll Tax

Outcome:	Not Working	Not Working	Retired	Retired
Effect of Age-Specific Payroll Tax	-0.018***	-0.016***	-0.010***	-0.006**
	(0.004)	(0.006)	(0.002)	(0.003)
Baseline Rate	0.266	0.277	0.161	0.156
Sample	Women	Men	Women	Men

Notes: Significance Levels: *10%, **5%, ***1%. Uses results from Tables V and VI to simulate effects of eliminating the employee portion of the payroll tax. We calculate after-tax labor income with and without the payroll tax, comparing the probabilities of not working and retiring. Standard errors in parentheses estimated using clustered (by household) bootstrap.

Table VIII: Effect of EITC Expansion

Outcome:	Not Working	Not Working	Retired	Retired
Effect of Age-Specific EITC Expansion	-0.060***	-0.031***	-0.034***	-0.013**
	(0.012)	(0.011)	(0.008)	(0.006)
Baseline Rate	0.266	0.277	0.161	0.156
Sample	Women	Men	Women	Men

Notes: Significance Levels: *10%, **5%, ***1%. Uses results from Tables V and VI to simulate effects of extending the EITC to workers ages 65+. We calculate after-tax labor income with and without the EITC, comparing the probabilities of not working and retiring. Standard errors in parentheses estimated using clustered (by household) bootstrap.

Table IX: Robustness Tests

Panel A: Robustness Tests								
Specification:	**Main Results**		**Pre-2009 Only**		**Labor Earnings Spline**		**Income × Year Controls**	
	(1) Women	(2) Men	(3) Women	(4) Men	(5) Women	(6) Men	(7) Women	(8) Men
1. Intensive Margin Equation - Outcome is $\Delta\ln$(Labor Income)								
$\Delta\ln$(1-MTR)	0.305	0.230	0.328	0.187	0.557	0.025	0.565	0.083
	(0.725)	(0.821)	(0.764)	(0.861)	(0.740)	(0.647)	(0.721)	(0.837)
2. Extensive Margin Equation - Outcome is I(Work)								
ln(After-Tax Labor Income)	0.554***	0.396***	0.632***	0.409**	0.580***	0.371***	0.544***	0.379**
	(0.123)	(0.152)	(0.174)	(0.176)	(0.192)	(0.142)	(0.166)	(0.170)
3. Simulations - Outcome is P(Not Working in $t+1$)								
Payroll Tax Simulation	-0.018***	-0.016***	-0.021***	-0.016**	-0.018***	-0.014***	-0.018***	-0.016**
	(0.004)	(0.006)	(0.006)	(0.007)	(0.006)	(0.005)	(0.005)	(0.007)
EITC Simulation	-0.060***	-0.031***	-0.069***	-0.033**	-0.061***	-0.030**	-0.059***	-0.030**
	(0.012)	(0.011)	(0.016)	(0.013)	(0.017)	(0.012)	(0.017)	(0.012)

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. The first row presents estimates from the intensive margin equation. The second row includes estimates from the extensive margin equation. The third row presents estimates from the payroll tax simulation while the final row performs the EITC expansion simulation. All estimates refer to semi-parametric adjustment results.
Columns (1) and (2) repeat the main results presented in earlier tables.
Columns (3) and (4) exclude the 2009 data from the analysis.
Columns (5) and (6) include a 5-piece spline in initial labor earnings.
Columns (7) and (8) include controls for initial adjusted gross income and labor earnings interacted with year dummies.

Panel B: Robustness Tests (Continued)						
Specification:	**Nonlinear Least Squares**		**Instrument constructed with 1999 sample**		**Trimmed Earnings**	
	(1) Women	(2) Men	(3) Women	(4) Men	(5) Women	(6) Men
1. Intensive Margin Equation - Outcome is $\Delta \ln$(Labor Income)						
$\Delta \ln$(1-MTR)	0.295	0.161	0.712	0.564	0.019	-0.000
	(0.656)	(0.693)	(0.885)	(1.094)	(0.143)	(0.174)
2. Extensive Margin Equation - Outcome is I(Work)						
ln(After-Tax Labor Income)	0.539***	0.381***	0.609**	0.356**	0.533***	0.366***
	(0.156)	(0.126)	(0.293)	(0.162)	(0.144)	(0.114)
3. Simulations - Outcome is P(Not Working in $t+1$)						
Payroll Tax Simulation	-0.023**	-0.018***	-0.021**	-0.015**	-0.018***	-0.014***
	(0.010)	(0.006)	(0.009)	(0.007)	(0.005)	(0.004)
EITC Simulation	-0.058*	-0.025***	-0.066***	-0.027**	-0.047***	-0.024***
	(0.033)	(0.008)	(0.023)	(0.011)	(0.011)	(0.007)

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. The first row presents estimates from the intensive margin equation. The second row includes estimates from the extensive margin equation. The third row presents estimates from the payroll tax simulation while the final row performs the EITC expansion simulation. All estimates refer to semi-parametric adjustment results.

Columns (1) and (2) estimate the intensive margin equation using nonlinear least squares.

Columns (3) and (4) use instruments constructed with the 1999 sample only. The 1999 sample is run through the tax code for each year and predictions are made for each year in the sample.

Columns (5) and (6) reassign labor earnings in period $t+1$ that are over 25% larger than labor earnings in t to 125% of initial labor earnings. Labor earnings in period $t+1$ that are under 75% of labor earnings in t are reassigned to 75% of initial labor earnings.

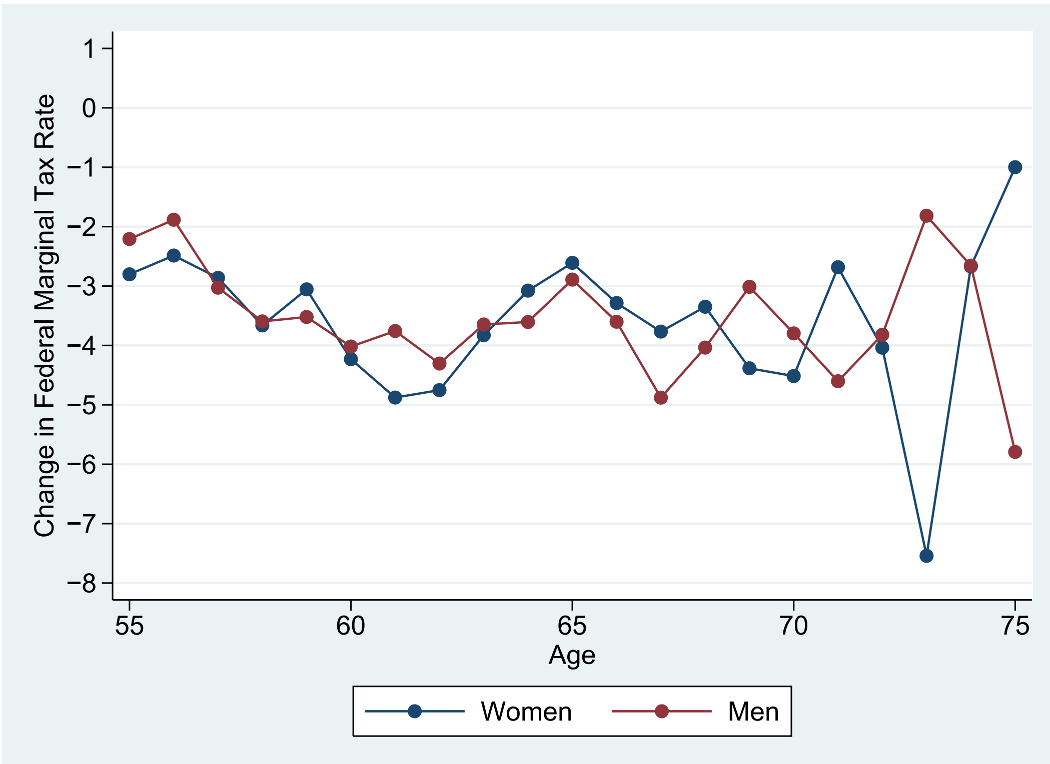
Table X: Part-Time Work and Tax Instruments

	Women	Men
Predicted $\Delta \ln$(1-MTR)	-0.081	0.500
	(0.336)	(0.416)
Predicted Δ in ln(After-Tax Income)	1.692	-1.155
	(1.093)	(1.137)

Notes: Significance Levels: *10%, **5%, ***1%. Standard errors in parentheses estimated using clustered (by household) bootstrap. Other variables included: year dummies interacted with marital status; interactions based on age group × education; spousal age group fixed effects. Initial income controls include flexible function for initial adjusted gross income and controls for initial labor earnings, spousal earnings, and family income. Semi-parametric selection adjustment also included.

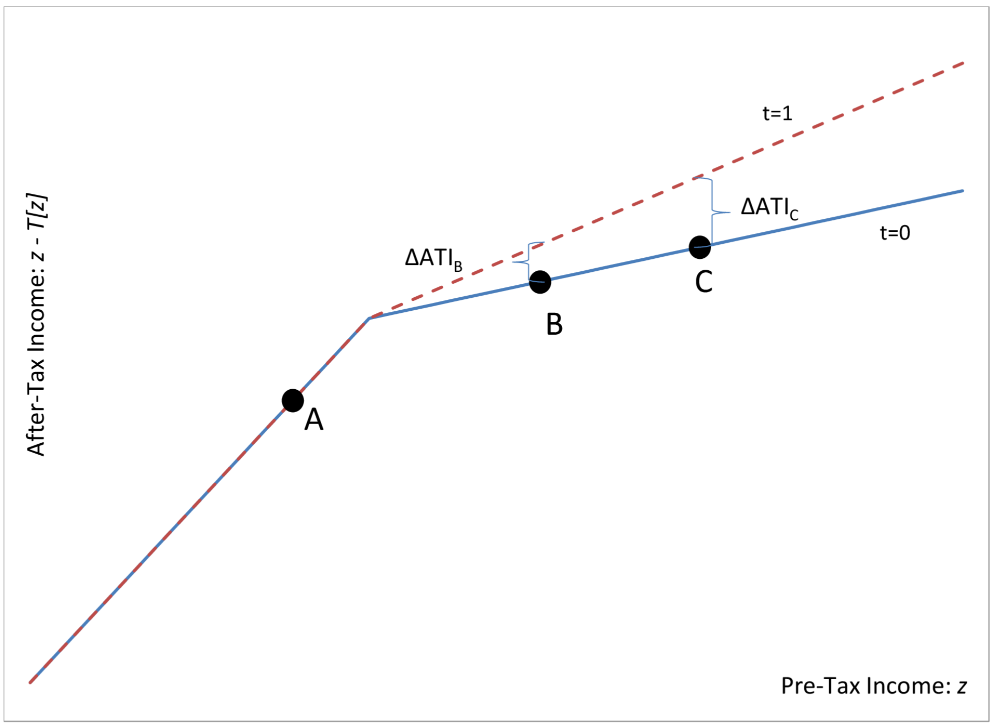
Figures

Figure 1: Change in the Marginal Tax Rate Between Year t and $t + 2$ by Age



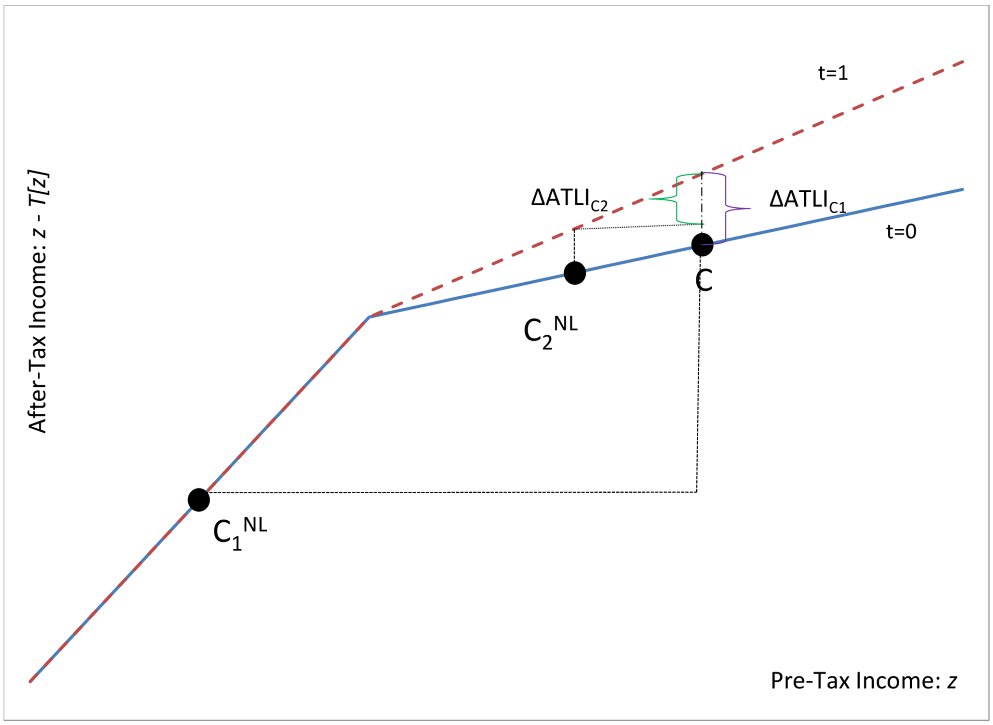
Notes: HRS 2000-2010 used to generate this figure. The marginal tax rates for year t and year $t + 2$ are calculated for each observation in our data. We calculate the mean change in the marginal tax rate and assign to age in period t.

Figure 2: Marginal Tax Rates and After-Tax Income



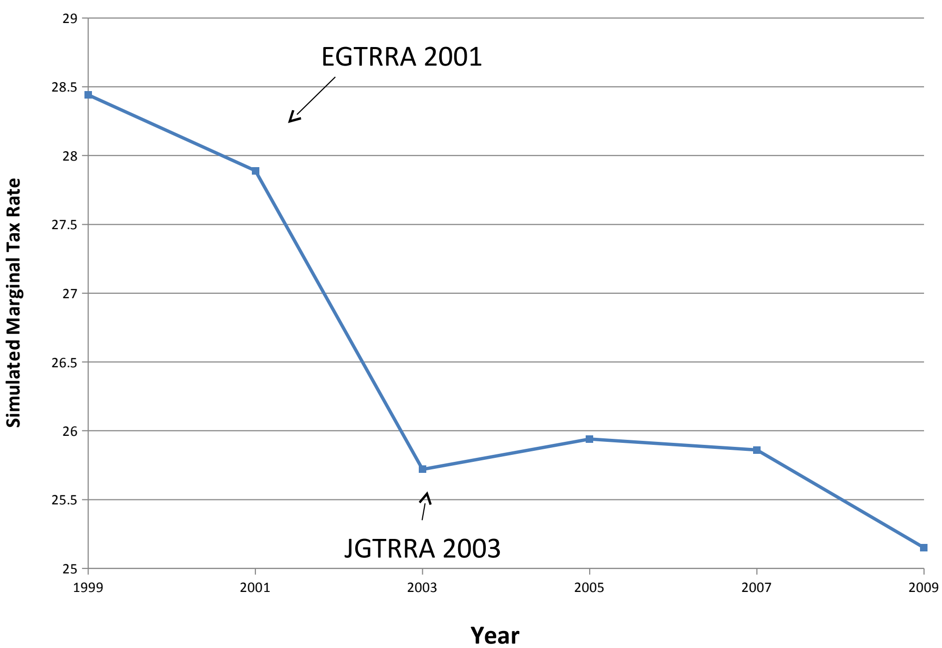
This figure graphs after-tax income as a function of pre-tax income for a tax schedule with two brackets. The marginal tax rate for the top bracket decreases in period $t = 1$. Holding pre-tax income constant, persons A and B experience different changes in their marginal tax rates. Persons B and C experience the same change in marginal tax rates but different changes in after-tax income (ΔATI).

Figure 3: After-Tax Labor Income



This figure is the same as Figure 2 but with a focus on Person C. Person C with very little non-labor income (C_1^{NL}) experiences a large increase in the after-tax incentive to work. Person C with more non-labor income (C_2^{NL}) experiences a smaller increase in the after-tax incentive to work. Both experience the same change in the marginal tax rate and after-tax income but different changes in the incentive to work.

Figure 4: Simulated Federal Tax Rates in HRS



Notes: Using our 2000-2010 analysis sample, we graph the simulated average marginal tax rate for each year, holding real income constant. To calculate the 1999 average marginal tax rate, we adjust all incomes to 1999 dollar and calculate the marginal tax rate under the 1999 tax code. We take the average to arrive at the simulated average marginal tax rate for 1999. We repeat this method for 2001, 2003, 2005, 2007, and 2009.