THE DESIGN OF RETIREMENT SAVING PROGRAMS IN THE PRESENCE OF COMPETING CONSUMPTION NEEDS

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INTRODUCTION

The standard lifecycle model is based on the retirement motive for saving – the need to transfer resources from the working life when income is predictably high to a planned period of retirement, when income is predictably low. Social Security is a government program designed to ensure that households engage in at least some lifecycle saving by changing their budget set in two important ways – it provides benefits for retirees, the disabled, and their survivors in the form of an indexed annuity, and it finances these benefits (net of income taxes) through a payroll tax levied on employees and their employers for earnings up to a maximum taxable earnings level. Under current law, the payroll tax is scheduled to be the same proportion of covered earnings in each year. If the Social Security system is actuarially fair, and if households would optimally be saving more than their payroll taxes for retirement during their working years, then the system will likely raise welfare through the longevity insurance it provides.

However, it is clear from empirical data on household saving that for many households these conditions are not met. In particular, the typical household: (1) has a low (or zero) desired saving rate or faces liquidity constraints over much of its working life, (2) has a saving rate that increases substantially in the years just prior to retirement, and (3) saves for several non-retirement reasons during those working years, including for housing, to make transfers to children, and as a precaution against income uncertainty. Recognizing the first two of these three, Hubbard and Judd (1987) and Hurst and Willen (2007) consider the further increases in welfare that can obtain from making the Social Security payroll tax depend on age. Specifically, they show that a revenue-neutral delay in the payment of Social Security taxes can raise welfare by allowing households to smooth their consumption more effectively over their working lives.

This paper builds on these prior studies by analyzing the third feature of pre-retirement saving – namely, the presence of competing saving and consumption needs over the working part of the household's lifecycle. The main results of this analysis derive from the need to accumulate resources in advance of the purchase of housing and the financing of college educations. For housing, traditional mortgages have down payment requirements that can only be met, or other financing constraints that can be relaxed, when assets are accumulated in advance of the purchase. For college, the student loan market is imperfect in that students and their families are typically unable to borrow the full costs of attending and must, therefore, have some resources available. The need to prefund the purchases leads to an interaction between the design of Social Security and saving for these motives through the lifecycle budget constraint. For example, making a revenue-neutral change to the payroll tax rates—lowering tax rates early in the lifecycle and raising them later in the lifecycle—would free up resources while households are young and saving for housing and college educations.

The key contribution of this paper is to build a comprehensive model of intertemporal consumption decisions that incorporates multiple reasons for saving.[1] To the standard lifecycle model in which retirement is the only motive, it adds income uncertainty, bequests, and stylized purchases of housing and college expenses. It incorporates both the current payroll tax schedule and a simplified version of the income tax schedule for a single individual. The model is parameterized to be consistent with empirical studies of income dynamics, asset accumulation, and expenditures on housing and college educations.

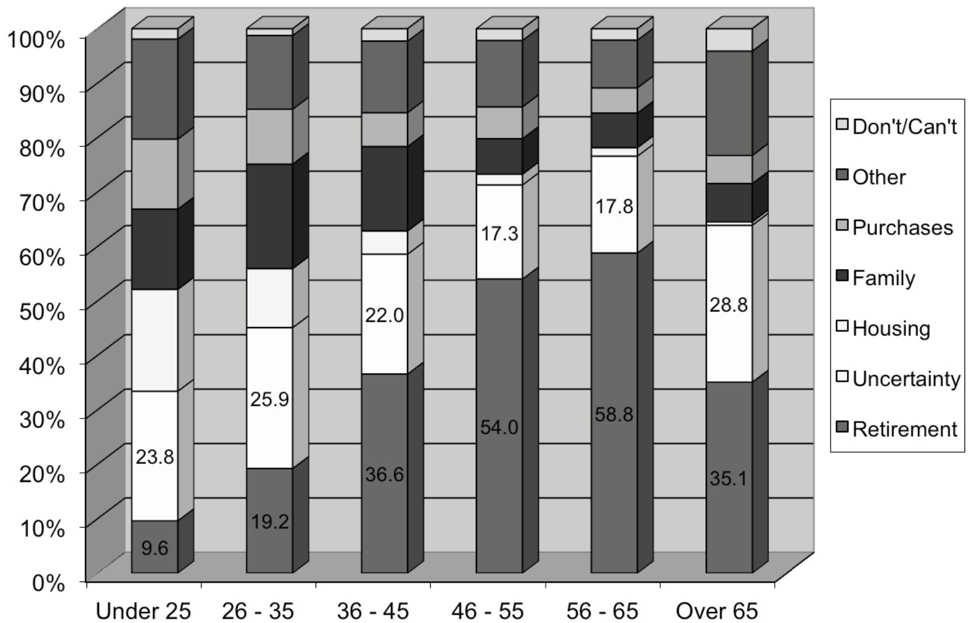
The model shows that the welfare gains from changes in the timing of the payroll tax depend broadly on the amount of saving that the individual is doing, for any reason. As an illustrative example, a 10-year, revenue-neutral delay in the onset of payroll taxes generates a welfare gain equal to approximately 18 percent of one year of annualized income. This is equivalent to giving a typical worker $8,000 of assets upon entering the work force. Welfare gains from revenue-neutral payroll tax delays are about eight percent (1.5 percentage points) larger when individuals must also save to overcome down payment constraints on housing purchases near the beginning of their work lives and three percent (0.5 percentage points) lower when they must save later in their work lives to finance college educations for their children.

WHY DO HOUSEHOLDS SAVE?

Figure 1 shows the distribution by age of households' self-reported primary reasons for saving from the 2007 Survey of Consumer Finances. The more narrow categories enumerated in the survey have been aggregated into the categories shown. The bottom category in each age group shows the percent of households reporting retirement as the primary motivation for saving. It increases steadily through the working years, from only 10 percent for those under 25 to 59 percent in the 56-65 age group.[2] The next most prominent reason for saving is against uncertainty, starting at 24 percent for the youngest households and falling to about 18 percent over the working years. Other identifiable reasons include housing, special purchases (e.g., consumer durables like vehicles and home furnishings), and for the family, which are relatively more important at younger ages than in the immediate pre-retirement period. All three are prominent for households under 25 years of age. "Family" becomes particularly important for those up to age 45, when saving for sending children to college often must be done.

The explicit study of saving motives has been largely excluded from the economics literature on saving and the design of retirement income programs. When economists study household saving decisions, the standard procedure is to focus on one motive, such as retirement, and make strong simplifying assumptions about the other motives so that they can be relegated to the background. The analysis below is designed as a first attempt to add saving to pre-fund specific needs – housing and college educations – into a model that has been used primarily to consider saving for retirement and uncertainty and bequests.[3]

Figure 1: **Primary Reasons for Saving by Age, 2007**



Source: Author's tabulations of the Survey of Consumer Finances, 2007

MODEL SPECIFICATION

The basic structure of the model is that in each period of life, s, the individual chooses a value of consumption, C_s, as a function of two state variables, current assets, A_s, and current income, Y_s. The individual's value function in period t, $V_t(A_t, Y_t)$, is the maximum achievable expected utility obtained when C_s is chosen optimally in each period. The model is solved backwards from the end of life, period by period, for optimal consumption rules, $C^*(A_t, Y_t)$, following the methods in Carroll (2001). These rules are then confronted by 5,000 independent lifetime income profiles beginning in the first period, yielding profiles for income, consumption, and assets in each subsequent period of life.[4]

The key outcome of the model is a value for the expected value of $V_1(A_1,Y_1)$, computed as the average value of the program across the 5,000 income profiles and a starting asset value of zero at the beginning of the work life. For a given set of preference parameters and consumption needs, the gain in expected utility from changing the individual's budget constraint is measured by the equivalent variation, κ: $V_1^1(A_1,Y_1) = V_1^0(A_1 + \kappa, Y_1)$. The equivalent variation indicates how much the individual would have to be compensated to remain under the original budget constraint to achieve the level of expected utility available under the new budget constraint. For simplicity, k is expressed as a percentage of equivalent annual income (EAI), defined as the constant amount of income received each year that has the same expected actuarial present value of the labor income and Social Security income actually received by the individual. The value κ is assumed to be available at the beginning of the working life, when a liquidity-constrained individual gets the most bang-for-the-buck for an additional dollar.

The baseline model consists of assumptions about the income process, preference parameters, the size of specific consumption needs, and the potential changes in the timing of payroll taxes by age. The variety of parameter configurations are chosen to illustrate the differences in the timing of saving over an individual's pre-retirement years. Specifically, the greater the individual's desire to consume at or above current income early in the lifecycle, the more valuable will be opportunities to delay the payment of taxes, even if the delay generates higher taxes later in the working life. In the model, a liquidity constraint is imposed that prevents the individual from borrowing.[5]

There are three aspects of the model that govern the desire to borrow early in the lifecycle. The first is the slope of the age-earnings profile. When earnings are expected to rise rapidly, there is less reason to save for lifecycle reasons. The simulations below use two of the income processes that have been estimated in the prior literature. Cocco, et al. (2005), hereafter CGM, used the Panel Study of Income Dynamics to estimate an age profile for total family non-capital income (i.e. including both spouses, if present, and income from social insurance and transfer programs) as a third-order polynomial in age. The CGM profile used here is for the lowest education group in that study. Murphy and Welch (1990), hereafter MW, estimate a fourth-order polynomial in age for individual earnings (not total family income). The age-earnings profile from their study (averaged across all education groups) is based on log earnings for a sample of white males in the Current Population Surveys.[6] Individuals facing the steeper MW profile are more likely to face binding liquidity constraints, while those facing the CGM profile can be expected to begin saving earlier in their working lives.[7]

The second key aspect of the model is the degree of income uncertainty faced. The MW and CGM profiles are for average income by age, or permanent income in the model. Around this average is uncertainty, captured by an AR(1) process with parameters of $\rho = 0.95$ and $\sigma = 0.15$.[8] Simulations are presented with and without this uncertainty present, i.e. $\sigma = 0$, in which case individuals can consume more early in life without the need to save for precautionary reasons.

The third key aspect of the model is the rate of time preference. If the rate of time preference is similar to the real interest rate in the model (here three percent per year), then the individual will seek to balance consumption across periods. As the rate of time preference rises relative to the interest rate, current consumption (and the desire to borrow in the present) rises. To capture this difference, the discount rate takes one of two values. For simulations of a "patient" consumer, the rate of time preference is assumed to equal the interest rate at three percent. For simulations of an "impatient" consumer, the rate of time preference is assumed to be eight percent. The two values represent different parts of the distribution of discount rates estimated in Samwick (1998). A patient consumer begins saving for retirement early in the lifecycle, while an impatient consumer typically delays saving for retirement for some portion of the lifecycle.[9]

The specific consumption needs are modeled as deductions from the amount of resources available for other consumption at specific ages, $z_s(A_s,Y_s)$. At this stage, three simplifications have been imposed on the way these needs are modeled. First, the individual is assumed to have no choice as to whether to pay for these consumption needs. Second, the individual is assumed to know precisely the years when these consumption needs will arise. Third, the consumption needs are modeled as functions of assets and labor income rather than fixed dollar amounts.

For the purposes of the simulations, the specific consumption needs of the individual are calibrated to a typical household's experience. The individual is assumed to have one child to put through college. Mathews and Hamilton (2002) report that in the 2000 Census, the average age of a mother at the birth of a first child was 25 and 27 was average age of a mother at the birth of any child. Choosing 18 as the child's age upon enrollment, the individual is assumed to incur college costs for four years beginning in at 45 years of age.

College expenses are as determined by the Expected Family Contribution (EFC) in the standard financial aid formula for a family of three with one child in college. In brief, the formula specifies an EFC that is non-decreasing in both income and assets. With income for these purposes defined as labor income, the two key determinants of the EFC are the state variables in the model, making it straightforward to implement.[10] Since the most expensive colleges now have total costs of about \$50,000 per year,[11] annual costs are capped at this amount regardless of income or assets.

The individual is assumed to make the transition to homeownership in the 12th year of the working life, or 32 years of age. Data on housing ownership and income from the 2007 Survey of Consumer Finances presented in Bucks et al. (2009) show that 66 percent of households aged 35 – 44 are homeowners. These data further show that for households under age 65, the ratio of house values to income varies between 4.0 and 5.3, while the ratio of mortgage debt to income falls from an initial value of 4.1 to 2.0 over the working life. Given these ratios, along with typical down payment requirements of 10 – 20 percent of the purchase price, a reasonable figure for the amount of the down payment is 50 percent of a current year's income. The required consumption amount is therefore 50 percent of income in the 12th year of the working life that begins at 21 years of age.

The simulations below distinguish between the existing payroll tax, which does not vary by age, and alternatives in which the payroll tax rates are lower at younger ages and higher at older ages. In 2009, a payroll tax of 12.4 percent for Social Security is levied on earnings up to a maximum taxable earnings limit of \$106,800.[12] A further 2.9 percent payroll tax for the hospital insurance portion of Medicare is levied on all earnings. Following Hubbard and Judd (1987) and Hurst and Willen (2007), payroll tax changes are implemented by delaying the onset of the payroll tax until specified ages, and then implementing it at a sufficiently high rate such that the alternatives have the same expected tax revenue collections as the existing system. Two alternatives are considered: one in which payroll taxes are delayed for 10 years and one in which payroll taxes are delayed for 20 years.[13] The key parameters are, therefore, the increases in the payroll tax rates when they are eventually implemented. The parameters differ for the two age-income profiles, with the shift being greater for the CGM profile because its early years have relatively higher income. For the CGM profile, the payroll tax rates must be raised by factors of 1.4211 and 2.3803 for delays of 10 and 20 years, respectively. Focusing on the employee's share of the payroll tax, this requires the uniform rate (under the maximum taxable earnings) to rise from 7.65 percent to 10.87 and 18.21 percent, respectively. For the MW profile, the corresponding factors are 1.2673 and 1.9634 and the corresponding tax rates are 9.70 and 15.02 percent, respectively. Given the partial equilibrium nature of the model and the absence of a labor/leisure decision, changes in the timing of the employer's share of the payroll tax are not analyzed in the present analysis.[14]

CONSUMPTION NEEDS AND ALTERNATIVE TAX SCHEDULES

As modeled above, the impact of specific consumption needs on individual welfare is negative. Purchasing a house or sending a child to college requires some pre-funding. This pre-funding must come at the expense of other consumption that the individual would like to enjoy. Payroll taxes depress consumption whenever they are levied.

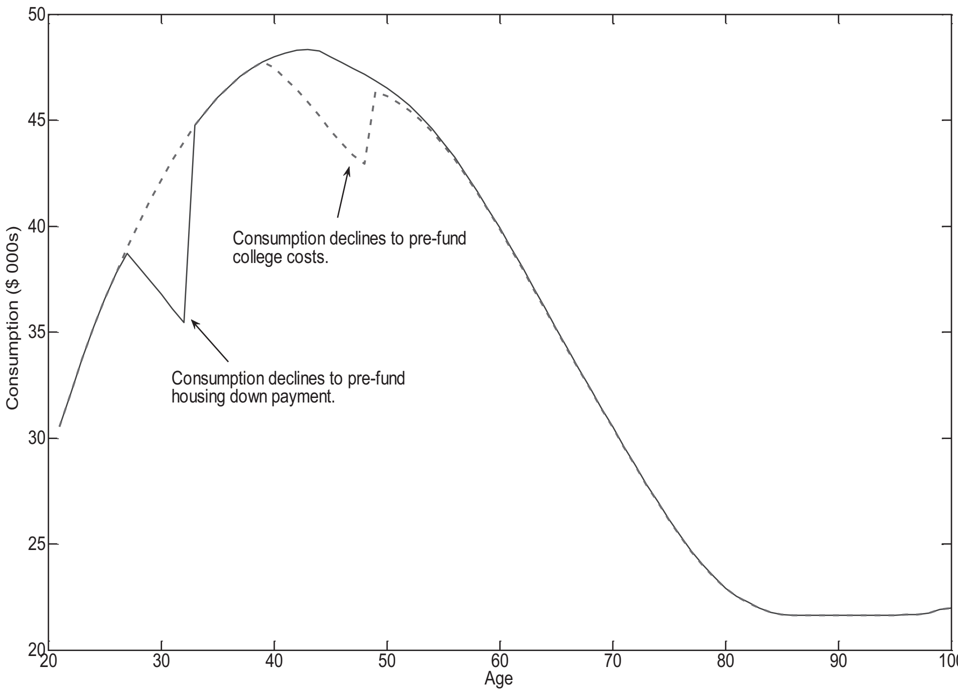
For liquidity constrained individuals, payroll taxes are particularly harmful to expected utility because they force a household that would like to borrow to do additional "saving." This section considers the interaction between such revenue-neutral shifts and the presence of specific consumption needs.

Figure 2 shows the average consumption profiles for two individuals: one facing a down payment constraint equal to 50 percent of his income at age 32, and one facing college costs at ages 45 – 48 as given by the EFC. The other parameters of the consumption problem match the impatient individual facing the CGM income process with no uncertainty. In each case, consumption begins to decline a few years prior to the age at which the specific consumption need begins. After those needs are met, consumption reverts back to the profile that prevailed in the absence of the specific needs. The welfare loss due to the consumption need is captured by these reductions in other consumption.

Figure 3 shows the impact of revenue-neutral delays in the timing of the payroll tax on the consumption profile of the impatient individual facing the CGM income profile without uncertainty or specific consumption needs. These delays enable the consumption profiles to start out higher and remain there until the payroll taxes commence. After that time, consumption is lower for the remainder of the lifecycle, the more so the longer the delay. Given the rising income profile, compounded by impatience, this is a shift that makes the individual better off.

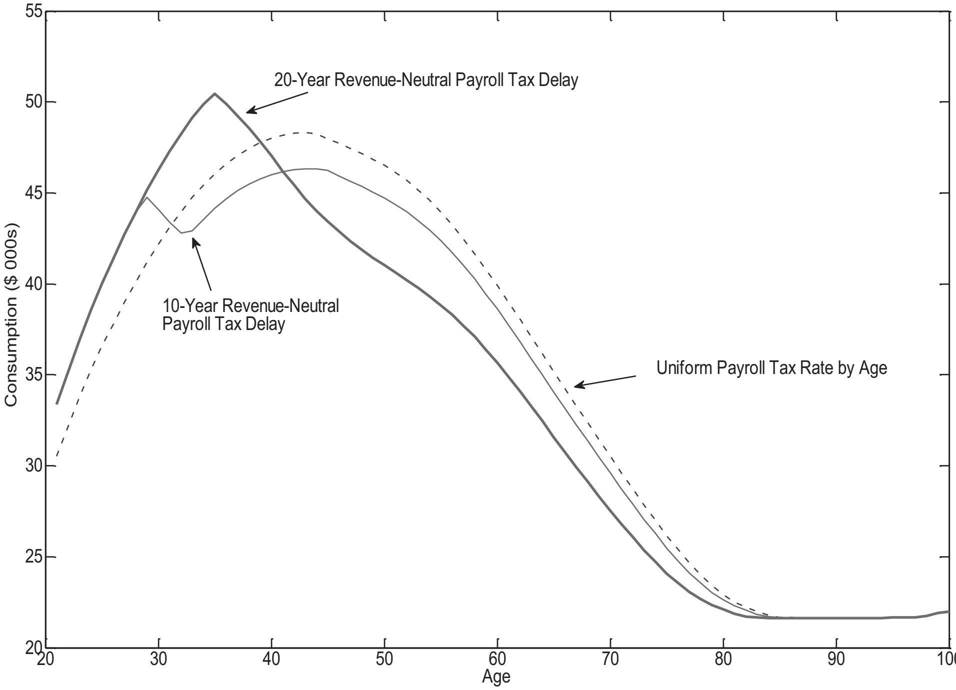
The top panel of table 1 shows the equivalent variations from a 10-year revenue-neutral delay in the payroll tax for eight parameterizations. Focusing on Parameter Group A in the first row of the table, an impatient individual facing the MW income profile and no income uncertainty would value the 10-year delay as equivalent to starting his working life at age 21 with an initial wealth of 17.26 percent of his equivalent annual income. For

Figure 2: **Average Consumption Profiles, Impact of Consumption Needs**



Notes: Figure shows the consumption profiles for an Impatient individual facing the CGM income profile and no income uncertainty.

Figure 3: **Average Consumption Profiles, Impact of Payroll Tax Shifts**



Notes: Figure shows the consumption profiles for an Impatient individual facing the CGM income profile and no income uncertainty.

individuals facing the MW profile, the equivalent variation is about 17 percent of EAI, regardless of whether they are patient or impatient or whether they face uncertainty in their income process or not. For individuals facing the CGM income profile, the equivalent variation is much higher for the impatient individual at 28.56 ($\sigma = 0$) or 26.07 ($\sigma = 0.15$) percent of EAI and somewhat lower for the patient individual at 9.96 ($\sigma = 0$) or 12.79 ($\sigma = 0.15$) percent of EAI. Overall, a simple average of the eight parameter groups gives an equivalent variation of 18.19 percent of EAI. Applying that average to the average EAI ($40,536 for MW; $51,227 for CGM) yields $8,346. Implementing a 10-year revenue-neutral delay in the payroll tax would generate a welfare gain comparable to giving each individual about $8,000 upon entering his working years.

The next column of table 1 shows the equivalent variations when the individuals have a need to prefund a down payment on a house at 32 years of age. For each parameter group, the equivalent variation is higher than in the first column when the housing need was absent. The payroll tax delay is more valuable when the housing need is present, because it defers most early tax payments that would come from low- (or no-) saving individuals until after the housing purchase is made. Averaging across the eight different parameter groups, the equivalent variation is now 19.66 percent of EAI, an increase of 1.47 percentage points or eight percent of the baseline value of 18.19 percent.

The final column of table 1 shows the equivalent variations when the individuals have a need to pay for four years of college expenses beginning at 45 years of age. The equivalent variations are positive but somewhat less than when the college need was absent. Taking the simple average across the eight groups, the equivalent variation is now 17.72 percent of EAI, a reduction of 0.47 percentage points or three percent of the baseline value when the consumption need was absent. What accounts

Table 1
Equivalent Variations for Revenue-Neutral Payroll Tax Delays

Parameter Group	*Discount Rate*	*Income Profile*	*Income Shock*	*Consumption Needs*		
				Neither	*Housing*	*College*
			10-Year Delay			
A	8%	MW	0%	17.26%	17.71%	17.20%
B	8%	MW	15%	17.35%	18.01%	17.31%
C	8%	CGM	0%	28.56%	30.78%	27.97%
D	8%	CGM	15%	26.07%	28.42%	25.70%
E	3%	MW	0%	17.00%	17.89%	16.83%
F	3%	MW	15%	16.54%	17.67%	16.37%
G	3%	CGM	0%	9.96%	13.08%	8.71%
H	3%	CGM	15%	12.79%	13.71%	11.68%
Average				18.19%	19.66%	17.72%
			20-Year Delay			
A	8%	MW	0%	20.32%	22.32%	20.07%
B	8%	MW	15%	21.40%	23.71%	21.25%
C	8%	CGM	0%	35.71%	42.15%	34.29%
D	8%	CGM	15%	36.20%	41.40%	35.00%
E	3%	MW	0%	17.63%	20.46%	17.17%
F	3%	MW	15%	19.92%	22.99%	19.26%
G	3%	CGM	0%	2.84%	7.11%	-2.85%
H	3%	CGM	15%	15.43%	17.42%	12.07%
Average				21.18%	24.70%	19.53%

Notes:

1) Equivalent variations are the amount that an individual facing an age-invariant payroll tax would need in order to be as well off as an individual facing the revenue neutral delay in payroll taxes.

2) Equivalent variations are specified as percentages of Equivalent Annual Income, defined as the amount of income that if received each year, would have the same expected present value as the specified income process.

3) MW refers to the income profile generated from Murphy and Welch (1990). CGM refers to the income profile from Cocco, Gomes, and Maenhout (2005). Equivalent annual income is equal to $51,227 (CGM) or $40,536 (MW).

4) Under the 10-year delay, payroll taxes are zero for 10 years and then increase by factors of 1.4211 (CGM) or 1.2673 (MW) relative to the current age-invariant rates for the remainder of the working life.

5) Under the 20-year delay, payroll taxes are zero for 20 years and then increase by factors of 2.3803 (CGM) or 1.9634 (MW) relative to the current age-invariant rates for the remainder of the working life.

for this reduction? Recall that the payroll tax deferral is not presented as an option – it changes the individual's budget constraint in the same way that a loan at an interest rate of three percent would change it. If the individual wanted to save most of the payroll tax reduction, he would have to pay taxes on the incremental saving and not achieve the full three percent rate of return. Since the college needs occur 15 years after the deferral ends and the "loan" begins to be repaid, there is considerably more saving of the payroll tax deferral involved with the college needs than with the housing needs.

The bottom panel of table 1 presents the analogous results for a revenue-neutral payroll tax delay of 20 years. When neither consumption need is present, the equivalent variations are higher than for the 10-year delays in table 1 for seven of the eight parameter groups. The simple average of those groups yields an equivalent variation of 21.18 percent, an increase 2.99 percentage points or 16 percent compared to the 18.19 percent for the 10-year delay. As with the 10-year delay, the introduction of the housing need increases the value of the 20-year payroll tax delay. Because of the longer delay, the impact is even larger – the average equivalent variation rises from 21.18 to 24.70 percent of EAI, an increase of 3.52 percentage points or 17 percent. Similarly, the welfare gains are in all but one case positive, when the individual faces the college need, though reduced, compared to when the need was absent. The average equivalent variation is now 19.53 percent of EAI, a reduction of 1.65 percentage points or eight percent compared to the baseline of 21.18 percent.

CONCLUSION

The Social Security system relies primarily on the payroll tax for financing – a tax that is applied to earnings regardless of the age of the worker. This paper considers the scope for welfare gains from revenue-neutral payroll tax delays in the presence of potential liquidity constraints and non-retirement reasons for saving, including income uncertainty, housing down payments, and college costs. As in prior studies such as Hurst and Willen (2007) and Hubbard and Judd (1987), the welfare gains are found to be positive, with an illustrative example of 18.19 percent of equivalent annual income in initial assets for a 10-year delay and 21.18 percent for a 20-year delay. Given the values of equivalent annual income for the income profiles used here, the equivalent variation for the 10-year delay translates into the same welfare gain as giving each individual about $8,000 in assets at the beginning of his working life. This gain comes solely from changing the timing of payroll taxes, not their levels.

Extending the prior literature, this paper shows that the welfare gains are of comparable magnitudes when income uncertainty and, thus, a precautionary motive for saving are added to the analysis. It also shows that in the presence of an asset constraint early in the lifecycle, modeled here as the need to accumulate a down payment for a housing purchase, the welfare gains to revenue-neutral payroll tax delays are somewhat higher. The illustrative welfare gains rise to 19.66 and 24.70 percent of annualized income for the 10- and 20-year delays, respectively.

For consumption needs that arise later in the lifecycle, such as paying college expenses for children, the welfare gains from revenue-neutral payroll tax delays are generally still positive but smaller than without those costs. The need to save most of the payroll tax deferrals for an extended period of time in a taxable account erodes some of their value. The welfare gains are 17.72 and 19.53 percent of annualized income for the 10- and 20-year delays, respectively. See Samwick (2011) for a discussion of possible extensions to this line of research, including a more complete impact of housing, children, and education spending on the intertermporal budget constraint and labor supply over the lifecycle as well as related literatures on age-specific taxation systems.

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Notes

1 For reasons of space, only an overview of the model is described below. For a complete description and more extensive analysis, please see Samwick (2011).

2 In Samwick (2011), I provide further evidence from the Surveys of Consumer Finances on why models of household savings need to be extended to incorporate multiple saving motives. Specifically, households save too little over their working lives and too late during their working lives for retirement to be a primary motive for saving at young ages. The typical household age 60 now has about 16 months of income in financial assets, with a disproportionate share accumulated in the prior 10 years. Additionally, most households report a time horizon for saving that does not extend to their retirement age. The percentage reporting that their most important horizon for saving and spending decisions is a few years or less is 80 percent for households under age 25 and falls to 48 percent for age 46 to 55 households.

3 See Samwick (2006) for a more extensive discussion of the importance of heterogeneity of saving motives.

4 The model is set up so that the individual enters the workforce at age 21, retires at age 65, and lives to a maximum age of 100 according to the survival probabilities in Arias (2007).

5 This is a simplification that nonetheless acknowledges the credit constraints that prevent individuals from borrowing too heavily against future income outside of a secured or collateralized relationship. The outcomes of the model are not greatly affected by allowing a fixed amount of unsecured borrowing. An alternative credit constraint would be to include a much higher rate for borrowing that would discourage, but not prohibit, large amounts of unsecured borrowing. See Hurst and Willen (2007) for an analysis of consumption and Social Security with a richer modeling of credit constraints.

6 Murphy and Welch (1990) present results for log weekly earnings. The MW and CGM profiles are both adjusted to constant 2009 dollars and initiated at a level of income at age 21 such that they generate replacement rates for a typical worker with medium earnings in the Social Security system, as provided at http://www.ssa.gov/OACT/TR/2009/lr6f10.html.

7 In this model, the individual retires at a planned date that is known from the beginning of the working life. At retirement, income is given by the Social Security benefit formula, denoted here by a function PIA, for the primary insurance amount that a worker earns based on earnings covered by the system. The benefit formula used is based on the 2009 schedule, simplified slightly to avoid the need for additional state variables in the model related to the use of the highest 35 years of indexed earnings to compute benefits. See Samwick (2011) for further details.

8 These parameters have become standard in the precautionary saving literature since the work of Hubbard, et al. (1995). The leading alternative is a random walk model in which the AR(1) coefficient is one, as in CGM. Either assumption would be fine for the present purpose, which is to compare the simulations for individuals who face realistic amounts of income uncertainty to simulations for individuals facing no uncertainty and, thus, without a precautionary motive for saving.

9 There are three additional preference parameters. The utility of consumption is of the constant relative risk aversion form, $u(c) = c^{1-\gamma}/(1-\gamma)$, with the coefficient of relative risk aversion, γ, assumed to be three. The two preference parameters pertaining to the utility of bequests, ϕ_1 and ϕ_2 in $v(A) = \phi_1^*((\phi_1 + A)^{1-\gamma})/(1-\gamma)$, are set to values of one and $24,000, respectively. These values are chosen to de-emphasize the bequest motive for saving relative to prior literature, such as Ameriks et al. (2007), in which bequest motives were the central focus. Specifically, ϕ_1 is lower and ϕ_2 is higher, such that in the simulations below we observe individuals spending down their assets steadily at the end of life rather than maintaining or building a large bequest.

10 A detailed grid of the EFC for various asset and income combinations can be viewed at http://www.finaid.org/calculators/quickefcchart.phtml.

11 See, for example, http://www.campusgrotto.com/most-expensive-colleges-for-2008-2009.html. According to Sutton (2009), the College Board reports that annual tuition and fees for two-year public colleges were $2,402 for 2008-2009, $6,585 for four-year public colleges, and $25,143 for four-year private colleges.

12 The 12.4 percent tax includes coverage for disability insurance, but the impact of disability is not modeled in this paper. See Chandra and Samwick (2008) for a similar model that incorporates the risk of disability.

13 Note that the equivalence holds only in expected value. An individual whose income shocks are positive early in life and negative later in life will pay lower taxes under the delayed payroll tax system. The opposite is true for a worker whose income shocks are negative early in life and positive later in life.

14 The model also incorporates the personal income tax schedule. In the model, income tax liability is a function of two arguments – labor income and saving in the single riskless asset paying a fixed return. The individual's taxes are calculated based on the 2009 tax schedule for a single taxpayer who does not itemize deductions and receives all capital income as interest or dividends rather than capital gains.

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