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The Effect of Income Taxation on Consumption and Labor Supply: New Implications for the Optimal Income Tax

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Personal income taxes make disposable income and, in turn, consumption less variable, which provides welfare-improving consumption insurance (Auerbach and Feenberg 2000; Cohen and Follette 2000; Kniesner and Ziliak 2001a; Strawczynski 1998; Varian 1980). Holding tax revenues constant, the degree of consumption insurance increases with the progressivity of the tax schedule. It is well established that the deadweight loss from reduced incentives to work and save is likewise increasing in the progressivity of the tax code (Auerbach 1985; Auerbach and Slemrod 1997; Auerbach and Hines 2002; Blundell, Duncan, and Meghir 1998; Bosworth and Burtless 1992; Carroll, Holtz-Eakin, Rider, and Rosen 1999; Hausman 1981; Ziliak and Kniesner 1999). A more complete understanding of the economic implications of tax reform requires an evaluation of the offsetting welfare gains and losses from the static versus dynamic efficiency effects caused by changes in the structure of personal income-based taxes. We exploit the natural experiments of the tax reforms of the 1980s and 1990s in the United States to examine empirically the effect of income taxes on life-cycle consumption and labor supply; we then infer the net welfare effects of alternative tax structures that consider the tradeoffs between the efficiency and insurance dimensions of an optimal income tax.

Estimating the impact of income taxes on labor supply has been a focal point of research by labor and public economists for nearly three decades. (See Blundell and MaCurdy (1999) and Pencavel (1986) for surveys.) A positive compensated wage effect means that moving to a flatter income tax induces more hours worked and reduces deadweight loss. Although there has been much disagreement over the years on the magnitude (and sometimes even the sign) of compensated wage effects, there is an increasing consensus toward a small positive compensated elasticity of hours supplied with respect to the wage rate. For example, Ziliak and Kniesner (1999) estimate that the compensated wage elasticity ranges from 0.13 to 0.18 across wealth quartiles, which implies a deadweight loss from the recent U.S. income tax structure of about 20 percent.

Unlike labor supply, there is comparatively little research on how income taxes implicitly stabilize consumption expenditures. Implicit income insurance exists because as before-tax income falls the household's tax burden also falls so that after-tax income drops by less than the drop in pre-tax income, which mitigates reductions in purchases of goods and services. Contrary to the welfare-enhancing effects of the flattening of the income tax during the 1980's operating through the labor-supply substitution effect, Kniesner and Ziliak (2002) estimate that a flatter rate structure by the end of the 1980s is welfare-reducing because households have greater variability of consumption. Their estimates indicate welfare losses from policy that reduced consumption insurance of upwards of six percent of baseline consumption for highly risk averse households facing large idiosyncratic income risks. Additionally Kniesner and Ziliak (2003) estimate that income-tax based consumption insurance is of comparable economic importance in the aggregate to insurance provided through the panoply of social insurance and means-tested transfer programs, automobile insurance, or health insurance.

To now, research that addresses simultaneously the incentive and insurance aspects of income taxes has been scarce (Krueger and Perri 2000; Low and Maldoon 2000; Strawczynski 1998; Varian 1980), and empirical work nonexistent. In addition, although previous empirical research has relaxed within-period separability between consumption and leisure (Browning and Meghir 1991; Blundell, Browning, and Meghir

1994), previous research has not considered income taxation in the context of more general specifications of inter-temporal preferences. We estimate a life-cycle model of consumption and labor supply that relaxes the standard assumption of strong separability within periods and permits the tax code to affect simultaneously the tradeoffs between efficiency costs of reduced incentives to work and insurance benefits of smoother consumption. Our results contribute to the consumption literature in general and narrow the gap in the literature between research on incentive aspects versus research on the insurance aspects of income taxes in particular.

We estimate within-period preferences over consumption and labor supply via the marginal rate of substitution function and a Stone-Geary felicity function. We then estimate inter-temporal preference parameters using the Euler equations governing the first-order conditions. The inter-temporal preference function admits increasing, decreasing, and constant relative risk aversion, which has shown to be important in the consumption insurance literature (Ogaki and Zhang 2001). Demographics are introduced into the model through the method of demographic translating, which means that demographics are entered directly into the parameters governing utility (Pollak and Wales 1992). The combination of within-period preferences and inter-temporal preferences permits us to identify both cross-sectional wage and tax elasticities, as well as inter-temporal elasticities. Because of the inherent non-linearity in the parameters, along with the endogeneity of variables, we use a generalized method-of-moments estimator.

To identify the tax effects on work incentives and consumption variability we use household-level data on male heads of household from the 1980–1999 waves of the Panel Study of Income Dynamics (1979–1998 calendar years). Our data are desirable because they contain multiple natural tax experiments: the five recent major federal tax reforms in the United States: the Economic Recovery Tax Act of 1981, the Tax Reform Act of 1986, the Omnibus Reconciliation Tax Acts of 1990 and 1993, and the Taxpayer Relief Act of 1997. The tax reforms of 1981 and 1986 jointly reduced marginal tax rates across-the-board, reduced the number of tax brackets from sixteen to four, and expanded the taxable income base. Although the tax reforms of the 1990s reversed the trend of the 1980s' reforms by adding two new higher marginal tax rates on upper-income Americans, they also significantly expanded the Earned Income Tax Credit among low-income working families. Table 1 below, taken from Kniesner and Ziliak (2003), summarizes the major changes in tax parameters.

The PSID collected comprehensive tax data for each household from 1980–1991 but stopped collecting the information beginning with the 1992 survey. Kniesner and Ziliak (2002) show that approximating tax rates and payments with a cubic polynomial in taxable income performs well relative to the PSID-generated tax data, and thus we use the smooth polynomial approximation to the tax structure. In addition to federal income taxes and income tax credits, we also control for payroll tax liability and an average state tax liability.

Our results to date indicate that consumption and hours both increase with an increase in the after-tax wage and the after-tax share. The uncompensated elasticity of labor supply of labor supply is about 0.4 on average, while the compensated elasticity is on the order of 1.2. Given an estimated inter-temporal elasticity of substitution of –1.38, the Frisch specific substitution elasticity of consumption with respect to the after-tax wage is about 0.75, indicating the households precautionary save by altering their optimal labor supply choice. Collectively our results indicate the scope for welfare gains through beneficial tax reforms.

II. A Model of Life Cycle Consumption and Labor Supply

The model of life cycle consumption and labor supply we adopt is standard in that the consumer is assumed to choose consumption and hours of work optimally in order to maximize the present discounted value of uncertain utility subject to an asset accumulation constraint.[1] Uncertainty arises due to the unknown paths of future wages, prices, taxes, and interest rates. Inter-temporal preferences are assumed to be time separable, as are budgets. The latter assumptions rule out preference dependence over time such as habits (Hotz, Kyland, and Sedlacek 1988), and also rule out non-separabilities in the budget constraint due to possible endogenous human capital and joint nonlinear taxation of wage and capital incomes (Blomquist 1985; Shaw 1989; Ziliak and Kniesner 1999). However, non-separabilities in within-period preferences over consumption and labor supply are not ruled out (Browning and Meghir 1991).

The value function governing the household's decision problem is

(1) $$V^t(A_t) = \max_{C_t, h_t} \{G[U(C_t, \overline{L} - h_t)] + \beta E_t V^{t+1}[(1+r_t)A_t + w_t h_t - p_t C_t - T_t(I_t)]\},$$

where A_t is the beginning of period *t* assets, *U*(.) is the within-period felicity function, *G*[.] is a monotonic transformation of within period preferences that governs inter-temporal preferences, C_t is non-durable consumption, $\overline{L}$ is total time available, h_t is annual hours of work, $\beta = 1/(1+\rho)$ is the time discount rate, E_t is the expectations operator conditional on the information set at time t, r_t is a risk-free interest rate, w_t is the gross hourly wage rate, p_t is the price index on non-durable consumption, and $T_t(.)$ is the household's income tax liability as a function of taxable income, $I_t = w_t h_t - D_t - Ex_t$, which is gross labor income less deductions (D_t) and exemptions (Ex_t). We assume that both the utility function and the tax function are twice continuously differentiable. In addition we normalize by the price of consumption so that wages and interest rates are in real terms.

The first-order conditions for consumption and hours from maximizing the value function are

(2) $$E_t[G'U_{C,t} - \beta(1+r_t)\lambda_A^{t+1}] = 0,$$

(3) $$E_t[-G'U_{h,t} + \beta(1+r_t)w_t(1-\tau_t)\lambda_A^{t+1}] = 0,$$

and

(4) $$\lambda_A^t = \beta E_t[(1+r_t)\lambda_A^{t+1}]$$

where G' is the first derivative of the inter-temporal transformation function, $U_{C,t}$ is the first derivative of within-period utility with respect to consumption, $U_{h,t}$ is the first derivative of utility with respect to hours of work, $\tau_t = \partial T_t(.)/\partial h_t$ is the marginal tax rate, and $\lambda_A^{t+1} = \partial V^{t+1}/\partial A_{t+1}$ is the marginal utility of wealth.

Substituting for λ_A^{t+1} in equation (3) using equation (2) (and noting that time t values are known) yields the familiar first-order condition for an interior solution, which equates the marginal rate of substitution of hours for consumption to the after-tax wage rate, $\omega_t = w_t(1-\tau_t)$,

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[1] A similar framework is found in Blundell, Browning, and Meghir (1994), Kniesner and Ziliak (1999), and

(5) $-U_{h,t}/U_{C,t} = \omega_t$.

It is clear from equation (5) that the monotonic transformation $G[.]$ plays no role in determining within-period consumption and hours allocations, and thus cross-sectional data are sufficient to identify intra-temporal preferences (MaCurdy 1983). On the other hand, to identify inter-temporal preferences it is necessary to have access to panel data (alternatively, time-series data or pseudo-panel data) and the Euler equation (4) governing the allocation of wealth over time.

Most of the literature on life cycle labor supply (for example, MaCurdy 1981) and life cycle consumption, including tests of full risk sharing, precautionary saving, and of the permanent-income hypothesis (for example, Cochrane 1991; Deaton 1991; Hall and Mishkin 1982), restrict intra- and inter-temporal preference parameters to be the same. An ex ante restriction that intra- and inter-temporal preference parameters be the same turns out to be costly in terms of reduced flexibility of behavioral responses to wage, price, and interest rate changes (Blundell, Fry, and Meghir 1988; Browning 1985).

For example, a familiar parameter in life cycle models of consumption is the inter-temporal substitution elasticity (ISE), which is the proportional change in expenditure needed to keep the marginal utility of wealth constant given an anticipated one-percent change in prices. Under the standard model with time-additive preferences the inter-temporal substitution elasticity is minus the inverse of the coefficient of relative risk aversion, $U_C/(CU_{CC})$. However, given the monotonic transformation in equation (1) the ISE is $U_C/\{C(U_{CC}+(G''/G')U_C^2)\}$, which will vary based on the choice of function

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MaCurdy (1983).

G (Browning 1985). Moreover, consider the Frisch (marginal utility of wealth constant) specific-substitution elasticity between any two goods *j* and *k*

(6) $$e_{jk}^{F} = e_{jk}^{U} + e_j e_k s_k \Phi ,$$

where e_{jk}^{F} is the Frisch elasticity, e_{jk}^{U} is the compensated cross-price elasticity, e_j and e_k are expenditure (income) elasticities, s_k is the share of good *k* in the household budget, and Φ is the ISE. Under the assumption that *G* is the identity transform and that within-period preferences are additive then $e_{jk}^{F} = e_j \Phi \approx e_{jk}^{Y}$ where e_{jk}^{Y} is the income-constant Marshallian cross-price elasticity of demand. The dual assumptions that within period preferences are additive and transform exactly into inter-temporal preferences are not innocuous as they rule out the very likely possibility that households precautionary save by altering their optimal hours choice (Heckman 1974; Low 1999).

A. A Tractable Empirical Representation

Our strategy is to adopt the two-stage estimation method of MaCurdy (1983) where in the first stage we estimate the equilibrium condition in equation (5) by specifying a functional form for within-period preferences that permits non-separabilities between consumption and labor supply choices. Given the estimated within-period preference parameters we construct the period-specific utility functions to estimate the inter-temporal preference parameters from the Euler equation (4).

We specify within-period preferences for household *i* in time period *t* with a Stone-Geary utility function

(7) $$U(C, \overline{L} - h) = (C_{it} - C_0)^{\eta} ((\overline{L} - h_{it}) - L_0)^{1-\eta} ,$$

where C_0 and L_0 are minimum sufficient values of consumption and leisure and are free parameters to estimate. Demographics are introduced into the model via the method of demographic translating whereby the utility parameters are explicit functions of characteristics, $\eta = \eta_0 + \sum_{k=1}^{K} \eta_k x_{itk}$ (Pollak and Wales 1992). Based on a demographically translated Stone-Geary specification of intra-temporal preferences we then estimate the natural log of the MRS condition in equation (5) as

(8) $$\ln \omega_{it} = \{\ln(1-\eta) - \ln((\overline{L} - h_{it}) - L_0)\} - \{\ln \eta - \ln(C_{it} - C_0)\} + \varepsilon_{it}$$

where ε_{it} reflects unobserved idiosyncratic tastes.

For the monotonic transformation G we specify preferences as

(9) $$G(U(C_{it}, \overline{L} - h_{it})) = \frac{(U(C_{it}, \overline{L} - h_{it}) - U_0)^{1+\sigma} - 1}{1+\sigma},$$

where $\sigma = \sigma_0 + \sum_{j=1}^{J} \sigma_j d_{itj}$ are the inter-temporal preference parameters that permit cross-sectional variation in risk aversion and the ISE, and U_0 is a free parameter indicating the minimum level of utility. Ogaki and Zhang (2001) show in an inter-temporal consumption model that does not distinguish intra- from inter-temporal preferences that (9) permits increasing, decreasing, and constant relative risk aversion and that such flexibility of risk tolerance affects tests of complete consumption insurance. Thus, we admit flexibility concerning estimated risk aversion into our model as well.

Combining the first-order condition for consumption (2) with equation (4) that governs the evolution of the marginal utility of wealth, taking expectations and natural logs, and then first differencing, the parameterization in (9) yields the estimating equation

(10) $$\sigma_0 \Delta \ln(\hat{U}_{t+1} - U_0) + \sum_j \sigma_j \Delta(d_{j,t+1} \ln(\hat{U}_{t+1} - U_0)) + \Delta \ln \hat{U}_{C,t+1} + \kappa_{t+1} = \nu_{t+1},$$

where Δ is the first difference operator, $\hat{U}_{t+1}$ and $\hat{U}_{C,t+1}$ are the estimated values of utility and marginal utility found by replacing η with $\hat{\eta}$ in equation (7), $\kappa_{t+1} = r_{t+1} + (\theta_t - \rho)$, $\theta_t = -E_t(\ln \zeta_{t+1})$, and $\ln \zeta_{t+1}$ is the time *t* forecast error uncorrelated with model variables. Note that in deriving equation (10) we exploit the fact that $\ln(1 + r_{t+1}) \approx r_{t+1}$ and that $\ln(1+\rho) \approx \rho$. Blundell, Browning, and Meghir (1994) observe that if ζ_{t+1} is lognormally distributed then $\theta_t = (1/2)\psi_t^2$, where ψ_t^2 is the variance of $\ln \zeta_{t+1}$, such that the quantity ($\theta_t - \rho$) captures the tradeoff between impatience and caution, which is a key element in determining the extent of precautionary saving.

III. Data and Estimation Issues

Our data come from the Panel Study of Income Dynamics (PSID) for interview years 1980–1999 (calendar years 1979–1998).[2] The survey has followed a core set of households since 1968 plus newly formed households as members of the original core have split off into new families. Following the 1997 survey year the PSID began interviewing households every other year; thus, there are no data for the 1997 calendar year. The PSID is advantageous because it contains detailed information on income and household composition. Our sample spans the major recent income tax reforms in the United States, which occurred in 1981, 1986, 1990, 1993, and 1997.

The sample we use is an unbalanced panel treating missing observations as random events. By eliminating only a missing person year of data, the time series for

[2] We begin our sample in 1980 because the PSID began collecting better tax information in 1980.

each household can be of different length within 1980–1999. To be included in the sample the household head must (1) be a male, (2) be in the sample at least five years, (3) be at least 25 years old in 1980, and (4) not be a student, permanently disabled, or institutionalized. Focusing on prime-age male heads of household allows us to ignore issues associated with labor force nonparticipation. To reduce further the influence of possible outliers we follow the existing literature and delete person-years with more than a 300 percent increase or more than a 75 percent decrease in consumption and family income. We also require annual food expenditures (inclusive of food stamps) to be no less than $520 and annual family income to be no less than $1,000. Using the four basic sample filters just mentioned we obtain 3,402 household heads over the 19-year sample. Because we require households to be present for five years, and because we invoke more detailed filters such as missing-data codes and extreme consumption and income changes, we retain 21,186 household-years for econometric estimation.

The focal variables in the models in equations (8) and (10) are consumption expenditures, labor supply, real wage rates, taxable income, marginal tax rates, total tax payments, interest rates, and demographics. We measure consumption as total non-durable consumption expenditures. The PSID only collects food expenditures on an annual basis, and failed to collect this information in the 1988 and 1989 surveys. However, Blundell, Pistaferri, and Preston (2001) recently proposed a method of imputing non-durable expenditures in the PSID. Using data from the Consumer Expenditure Survey (CEX) they estimated the demand for food at home as a function of measured demographics (available in both the PSID and CEX), food prices, and non-durable expenditures. Specifically, the model is

(11) $\ln(c_{it}^{f}) = X_{it}\varphi + \pi \ln(C_{it}) + e_{it}$,

where c_{it}^{f} is food expenditures in the home and C_{it} is non-durable expenditures. Given estimates $\hat{\varphi}$ and $\hat{\sigma}$ from the CEX, along with data on food and demographics in the PSID, it is possible to predict non-durable consumption as $\ln(\hat{C}_{it}) = (\ln(c_{it}^{f}) - X_{it}\hat{\varphi}) / \hat{\pi}$.[3] Provided that food expenditures are monotonic in non-durable expenditures, that the point estimates from the CEX are estimated consistently, and that the trends in the variance of non-durable consumption are the same across the CEX and PSID, this method produces a consistent estimate of non-durable expenditures in the PSID.[4]

Labor supply here is defined as annual hours of work from all jobs. For workers paid by the hour the survey records the gross hourly wage rate. However, given that the data after 1993 are still in the early release form the hourly wage is missing for many observations in certain years. Thus, we follow a procedure akin to the PSID's calculation of hourly wages for salaried workers. Specifically, for workers with annual hours less than 1000 we divide annual earnings by 750; for workers with hours between 1000 and 1800 we divide earnings by 1500; for workers with hours between 1800 and 2200 we divide earnings by 2000; and for workers with more than 2200 hours we divide earnings by 2400. Ziliak and Kniesner (1999) show that dividing earnings by standardized work

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[3] We use a scaled-down version of the prediction equation found in Table 4 of Blundell, et al. (2001). We predict non-durable expenditures as $\ln(\hat{C}_{it}) = (\ln c_{it}^{f}) - (3.6674 - 0.5746\ln(cpi_{t}^{f})) / 0.4573$. We are grateful to Luigi Pistaferri for providing us this information.

[4] A related method of predicted non-durable consumption in the PSID is found in Skinner (1987). He, too, used data from the CEX, but many of the variables needed to construct Skinner's measure are no longer collected by the PSID. Ziliak (1998) proposed a method of imputing total consumption in the PSID by netting out saving from income where it is necessary to first predict saving using wealth information in the PSID. Inferring consumption from saving measured by changes in wealth requires an additional year of data for each household to construct saving and is likely to be a more noisy measure of consumption.

years reduces so-called division bias that plagues wages computed as the ratio of annual earnings to actual annual hours (Borjas 1981).

When constructing annual taxable income we assume that married men filed joint tax returns and unmarried men filed as head of household. Adjusted gross income is the sum of the man's labor earnings plus interest income. Taxable income is adjusted gross income less deductions and exemptions. The Panel Study of Income Dynamics provides the number of tax exemptions for dependents taken in each year, but how we calculate deductions requires additional explanation.

Computing the value of deductions depends on the year under consideration. To evaluate annual deductions prior to and including 1983 we follow the convention established in the PSID. With information from the Internal Revenue Service's *Statistics of Income* we generate the typical value of itemized deductions based on the man's adjusted gross income. We then calculate the difference between typical itemized deductions and the standard deduction, known as excess itemized deductions. For the years prior to and including 1983 when excess itemized deductions are positive we subtract it from adjusted gross income; when excess itemized deductions are non-positive we apply the standard deduction.

Beginning in 1984 the PSID records whether the family itemized. For known itemizers we subtract excess itemized deductions from adjusted gross income and use the standard deduction for the men who did not itemize deductions. Prior to the Tax Reform Act of 1986 (TRA86) the standard deduction was built into the tax tables so that we only need subtract the value of deductions exceeding the standard deduction from taxable income. After TRA86 the standard deduction is no longer built into the tax tables so we subtract either the standard deduction or total itemized deductions from adjusted gross income depending on whether the family itemized.

The PSID stopped collecting information on household income tax liability after the 1991 interview year. Hence we approximate the income tax liability via several steps. First, using a method derived by MaCurdy, Green, and Paarsch (1990) and implemented by Ziliak and Kniesner (1999), we approximate federal income tax payments with a smooth cubic polynomial in taxable income. The idea is to act *as if* the household faces a smooth tax function rather than a piecewise-linear function and to approximate the marginal tax rate. Because the marginal tax rate is a smooth and continuously differentiable function of taxable income we can integrate the function back to obtain total tax payments. From total federal tax payments we net out the imputed Earned Income Tax Credit for each year (assuming a 100 percent take-up rate) and add in FICA (payroll) taxes and the relevant state income tax payments, which for tractability we take as a proportional tax on income with the tax rate determined by the average income tax rate in the state (State Government Tax Collections, 1980–1999 Tax Years).[5]

Lastly, for the demographics moderating the parameters η in the MRS equation we begin with a parsimonious specification with the number of children in the household, the race of the male head, and the age of the youngest child. The parallel demographics that affect risk aversion and the ISE are the age of the household head and the health status of the head. Appendix Table 1 contains selected summary statistics for the variables used in our econometric model that we now present.

[5] Details of the tax calculations are available from the authors upon request.

A. Estimation Issues

Estimation of equations (8) and (10) is complicated both because the models are nonlinear in the parameters and because the regressors are endogenous (hours, consumption, and wages in the MRS equation, and estimated utility and marginal utility in equation (10)). To deal simultaneously with nonlinear equations with endogenous regressors we adopt a nonlinear generalized method of moments (GMM) estimator (Hansen 1982). Specifically, given a $(1 \times Q)$ vector of instrumental variables for the MRS equation, z_{it}, the population orthogonality conditions we estimate for the first stage are $E[z_{it}'\varepsilon_{it}] = 0$. The analogous conditions for equation (10) are $E[m_{it}'\varepsilon_{it}] = 0$, where m_{it} is a $(1 \times M)$ vector of instrumental variables.

As instrumental variables for the MRS equation we use a constant and the $(t - 1)$ values of the head's age, the family size, the number of kids, the age of the youngest child, and dummy indicators for marital status, education, race, self-employment status, health status, home ownership, union status, and region of country. For the Euler equation (10) we use the $(t - 2)$ values of the latter variables along with twice lagged real after-tax wages, non-durable expenditures, and hours of work. All calculations are conducted in Gauss using the Newton algorithm.

IV. Results

In Table 2 we record the estimates of the MRS equation (8) in the top row and the estimates of the inter-temporal consumption function in the bottom row. We set the value of total time, $\overline{L}$, equal to 8760. Initial efforts to estimate the Stone-Geary model in (8) were unsuccessful due to lack of convergence in the threshold parameters C_0 and L_0. Thus, we set the parameters equal to 0, which yields the familiar Cobb-Douglas utility function for within-period preferences.

The estimates in Table 2 show that the marginal rate of substitution between hours of work and consumption is increasing in the number of children, the age of the youngest child, and for heads who are white. The implication, then, is that labor supply is higher for heads with more children, is higher for heads with older children relative to those with younger (or no) children, and is higher for white men relative to nonwhite men. Evaluated that the means of the variables $\bar{\hat{\eta}}$ = 0.27, or that leisure receives about 70 percent of the weight in the utility function. The parameter estimates are very precisely estimated, though the standard errors are not adjusted for the presence of repeated observations of the same individual. The Sargan test of the validity of the over-identifying restrictions is rejected, which may suggest model misspecification. We then replaced the current set of instruments with their corresponding values at $(t - 2)$ with a similar outcome. Failure to pass the Sargan test check is not likely to be because of poor instruments, then, but rather may be due to the assumption of no person-specific and time-invariant unobserved heterogeneity in the MRS equation. We will explore the issue of additional latent heterogeneity in the near future.

In the bottom row of Table 2 we record the estimates of the Euler equation for consumption. Here we see that risk aversion is declining in age and rising in ill health. The estimate of $(\theta_t - \rho)$ is a positive 0.10, suggesting that prudence outweighs impatience and that precautionary saving motives are present. Although convergence of the model with the utility threshold parameter, U_0, was attained the estimated value was poorly determined.

A. Intra- and Inter-temporal Elasticities

It is useful to characterize the estimates in Table 2 into terms useful for tax policy; namely, compensated and uncompensated wage and tax elasticities for within-period preferences, and the ISE and Frisch specific substitution elasticities for inter-temporal preferences. When closed-form solutions for within-period demand and supply functions are not available, MaCurdy (1983) observed that it is still possible to derive the implied compensated and uncompensated wage effects by exploiting a result in Phlips (1984) known as the fundamental matrix equation. We follow his method closely, and summarize it here for completeness.

Ignoring for the time being the monotonic transformation, G[.], we define the Hessian matrix for the utility function as H and the marginal utility of income as $\mu = U_{C,t} / p_t$. Further defining the price vector of interest as $q' \equiv [p_t, \omega_{it}]$, where recall p_t is the price of consumption normalized to 1 and ω_{it} is the real after-tax wage rate, and the relation $n \equiv q'H^{-1}q$ then the implied income effects, compensated effects, and uncompensated effects are

$$\begin{pmatrix} \partial C / \partial Y \\ -\partial h / \partial Y \end{pmatrix} = \frac{1}{n} H^{-1} q,$$

(11)
$$\begin{pmatrix} \partial C / \partial q' |_U \\ -\partial h / \partial q' |_U \end{pmatrix} = \mu H^{-1} - \frac{\mu}{n} H^{-1} q q' H^{-1},$$

$$\begin{pmatrix} \partial C / \partial \omega |_Y \\ -\partial h / \partial \omega |_Y \end{pmatrix} = \begin{pmatrix} \partial C / \partial \omega |_U \\ -\partial h / \partial \omega |_U \end{pmatrix} + \begin{pmatrix} \partial C / \partial Y \\ -\partial h / \partial Y \end{pmatrix} h \, .$$

The values in equation (11) are evaluated at the estimated parameters $\hat{\eta}$ and various points of interest for the variables, such as at the sample means or sample medians. Aside from the wage effects on consumption and labor supply, an important calculation for tax purposes is the responsiveness of consumption and labor supply to changes in the *after-tax share*, $(1-\tau)$, which is readily computed using the formulas above. For ease of interpretation we convert the marginal effects in (11) into point elasticities.

The elasticities derived from (11) tell only part of the story because lifetime considerations are a critical component in evaluations of tax reforms. The estimates of the monotonic transformation from the Euler equation for consumption provide the information necessary to construct the ISE, which given our parameterization is found by the ratio $\frac{(\hat{U}_{it}-\hat{U}_0)}{(\hat{\sigma}\hat{U}_{C,t}+(\hat{\eta}-1)(\hat{U}_{it}-\hat{U}_0))}$. Combining the compensated elasticities from (11) with the ISE and the associated consumption and hours income elasticities it is possible to construct the Frisch specific substitution elasticities of equation (6).

In Table 3 we report the within-period and inter-temporal elasticities implied by our point estimates from Table 2, evaluated separately at the sample means and medians of characteristics. We focus our discussion on the results evaluated at the mean values. The non-labor income elasticities of consumption and labor supply are 0.02 and –0.21. The corresponding utility-constant compensated wage elasticities of consumption and labor supply are 0.76 and 1.26. As seen by the uncompensated wage elasticity of labor supply of 0.39 the compensated estimate of 1.26 is driven by the sizable estimated income elasticity. The magnitude of the compensated wage elasticity of labor supply is above that typically reported in the literature and implies a very large deadweight loss of taxation. Although atypical the compensated wage elasticity we estimate is comparable to that reported in MaCurdy (1983) even though he employs a different specification of preferences and uses a much smaller dataset from an earlier time period (about 120 people for the years of 1972–1975 in the SIME/DIME). More work is needed to uncover fully the reasons why our estimated compensated wage elasticity is larger than in most earlier research, but it is suggestive that modeling consumption and labor supply jointly is quite important.

The estimate of the ISE at the means is –1.38, which is consistent with strictly concave inter-temporal preferences and is of comparable magnitude to that estimated by Blundell, Browning, and Meghir (1994) in their application to UK data. Given the ISE and compensated wage elasticities the Frisch specific substitution elasticity of consumption with respect to wages is 0.75. Our estimates imply that consumption and leisure are substitutes over time and that when wages are high so is consumption. As noted by Heckman (1974), and more recently by Low (1999), an implication of the direct co-movement in wages and consumption is that households precautionary save out of labor supply. Our estimates in Table 3 could therefore help resolve some discrepancies in the consumption and saving literature. Specifically, it is well known that saving by prime-age adults in the U.S. is very low, yet there is also strong evidence in Carroll and Samwick (2000) of a large precautionary saving motive in a model without labor supply. It is possible that the large precautionary saving that appears in a consumption model without labor supply is a spurious finding due to the absence of a labor supply margin with which to smooth consumption.

In Table 3 there is also evidence that increasing the after-tax share raises both hours of work and consumption. A 10 percent increase in the after-tax share results in a 0.7 percent increase in consumption and a 0.6 percent increase in total hours within a period; there is a 0.6 percent increase in consumption and a 2.4 percent increase in labor supply across periods based on the Frisch elasticity estimates. Collectively the elasticity estimates in Table 3 imply that welfare gains from increased labor supply and consumption are possible from tax reforms that raise the after-tax share.

V. Conclusion

We estimated a model of life-cycle consumption and labor supply whereby intra-temporal preference parameters were identified by estimating the equilibrium condition governing the optimal interior consumption and hours choices and inter-temporal preferences were estimated from the Euler equation for consumption. Our estimates to date indicate that labor supply responds positively to after-tax wage increases both within periods and across periods, and the various elasticity estimates conform to the a priori relative size ordering (Browning 1985). In addition, the estimated Frisch elasticity of consumption with respect to wage changes is positive and suggests that households precautionary save by altering their optimal labor supply choices.

Given the estimated preference parameters, we ultimately intend to turn to the issue of the implied welfare effects of the income tax and their implications for the optimal rate structure. Our next effort will be to simulate out the impact of tax reforms on consumption, labor supply, and economic well-being with regard to deadweight loss. The income tax reforms we plan to examine, each of which are revenue neutral, include moving from a progressive tax to: (i) a lump-sum tax; (ii) a flat tax; (iii) a flat tax with a standard deduction; and (iv) an across-the-board tax cut. Our estimates of labor-supply welfare gains in Ziliak and Kniesner (1999) and of the consumption-insurance welfare costs in Kniesner and Ziliak (2002) imply that reduced insurance from flatter tax structures may offset the welfare gains of greater work incentives by as much as one-third. The estimates in Table 3, however, are suggestive that net welfare is likely to be higher under the reforms we will consider, and that the relative offsetting welfare effect of a flatter tax structure via reduced consumption smoothing is relatively less (than one-third) when consumption and labor supply are considered jointly.

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Table 1. Changes in Selected Federal Tax Parameters, 1979–1999[a]

Income Tax[b]					
1979		**1989**		**1999**	
MTR (percents)	**Range ($1,000)**	**MTR (percents)**	**Range ($1,000)**	**MTR (percents)**	**Range ($1,000)**
0	0–3.4	15	0–30.95	15	0–43.05
14	3.4–5.5	28	30.95–74.85	28	43.05–104.05
16	5.5–7.6	33	74.85–177.72	31	104.05–158.55
18	7.6–11.9	28	177.72+	36	158.55–283.15
21	11.9–16.0			39.6	283.15+
24	16.0–20.2				
28	20.2–24.6				
32	24.6–29.9				
37	29.9–35.2				
43	35.2–45.8				
49	45.8–60.0				
54	60.0–85.6				
59	85.6–109.4				
64	109.4–162.4				
68	162.4–215.4				
70	215.4+				
Payroll Tax[c]					
6.13	0–22.9	7.51	0–48.0	6.20	0–72.6
				1.45	0–
Earned Income Tax Credit[d]					
1979 (range in $1,000)		**1989 (range in $1,000)**		**1999 (range in $1,000)**	
Phase-In Rate	**Phase-Out Rate**	**Phase-In Rate**	**Phase-Out Rate**	**Phase-In Rate**	**Phase-Out Rate**
10.0 (0–5.0)	12.5 (6.0–10.0)	14.0 (0–6.5)	10.0 (10.24–19.34)	7.65 (0–4.53)	7.65 (5.67–10.2)
				34.0 (0–6.8)	15.98 (12.46–26.93)
				40.0 (0–9.54)	21.06 (12.46–30.58)

[a]Data on the federal income tax and payroll tax parameters are from the Commerce Clearing House *U.S. Master Tax Guide* for 1980 and 1990, and from the 1999 Forms and Publications link on the IRS WebPages <http://www.irs.gov/forms_pubs/formpub99.html>. Data on the EITC parameters are from Ventry (2000).

[b]Federal income tax rates and ranges are for a married couple filing jointly. The Tax Reform Act of 1986 altered the definition of taxable income to eliminate the so-called zero bracket amount.

[c]Beginning in 1991 separate bases applied to the retirement and health-insurance portions of the payroll tax. The tax base is labor market earnings.

[d]Beginning in 1991, separate EITC parameters applied to families with one qualifying child versus more than one qualifying child. Beginning in 1994 the EITC extends to families with no dependents. The tax base is labor market earnings.

Table 2. Estimates of Intra-temporal and Inter-temporal Preferences

Marginal Rate of Substitution Parameters			
Constant	Children	Race (White = 1)	Age of Youngest Child
0.1254	0.0414	0.0494	0.0106
(0.0025)	(0.0012)	(0.0026)	(0.0034)

Consumption Euler Equation Parameters				
Constant	$\theta_t - \rho$	Age	Health (work limited = 1)	U_0/1000
–2.3153	0.1015	–0.0730	0.0447	–6.7405
(5.0669)	(0.0591)	(0.0636)	(0.0284)	(234.3747)

Notes: Asymptotic standard errors robust to heteroskedasticity are in parentheses. The computed value of the Sargan test statistic for not rejecting the over-identifying restrictions in the MRS equation is 1852 (df = 14; *p*-value = 0.00) and for the Euler equation is 45 (df = 16; *p*-value = 0.00).

Table 3. Selected Intra-Temporal and Inter-temporal Elasticities

	Consumption	Labor Supply
Real After-Tax Wage Changes		
Uncompensated Elasticity	0.843 [0.935]	0.397 [0.178]
Income Elasticity	0.020 [0.006]	–0.214 [–0.045]
Compensated Elasticity	0.762 [0.819]	1.262 [1.032]
Inter-temporal Substitution Elasticity	–1.384 [–1.349]	≅ 0.5
Frisch Specific Substitution Elasticity	0.757 [0.818]	1.313 [1.034]
Real After-Tax Share Changes		
Uncompensated Elasticity	0.065 [0.218]	0.060 [0.774]
Income Elasticity	0.013 [–0.024]	–0.307 [–0.329]
Compensated Elasticity	0.062 [0.255]	0.139 [1.265]
Frisch Specific Substitution Elasticity	0.057 [0.026]	0.243 [1.392]

Notes: The first numbers are evaluated at the mean values of characteristics while the numbers in square brackets are evaluated at median values of characteristics.

Appendix Table 1. Selected Summary Statistics

	Mean	Standard Deviation
Non-durable Expenditures	48.775	168.231
Annual Hours of Work	2.241	0.575
After-Tax Wage	12.478	7.940
Total Marginal Tax Rate	0.323	0.088
After-Tax Interest Rate	0.005	0.015
Age	38.024	6.548
Family Size	3.573	1.388
Number of Children	1.464	1.216
Age of Youngest Child	4.930	5.136
Marital Status (=1 if married)	0.878	0.327
Health (= 1 if work limited)	0.0713	0.257
Race (= 1 if white)	0.749	0.433
Less Than High School	0.186	0.389
High School Graduate	0.312	0.463
More Than High School	0.503	0.500
Self Employed	0.133	0.339
Home Owner	0.746	0.435
Union Member	0.244	0.430
Live in North East	0.173	0.378
Live in North Central	0.242	0.428
Live in South	0.405	0.491
Live in West	0.179	0.384

All income and price data are in real (1998) dollars using the personal consumption expenditure deflator.

Number of Person Years = 21,186