...entER
for
...nomic Research

Discussion paper

[redacted]

Tilburg University

Center
for
Economic Research

No. 9589

ESTIMATING LIFE-CYCLE LABOR SUPPLY TAX EFFECTS

By James Ziliak and
Thomas J. Kniesner

September 1995

ISSN 0924-7815

Estimating Life-Cycle Labor Supply Tax Effects

James P. Ziliak
Department of Economics
University of Oregon, Eugene

Thomas J. Kniesner*
Department of Economics
Indiana University, Bloomington

Revised June 1995

We are grateful to the editor and a very insightful anonymous referee for their help in improving our research. We also thank Karen Smith Conway, Ben Craig, Nicole Fortin, Les Godfrey, Daniel S. Hamermesh, Arie Kapteyne, Lee Lillard, Thomas MaCurdy, Charles Manski, Costas Meghir, Chris Orme, Robin Sickles, Pravin K. Trivedi, Ian Walker, Finis Welch, David Wildasin, and audience members for presentations at the Winter Meetings of the Econometric Society, The Bureau of Labor Statistics, Case-Western Reserve University, East Carolina University, Office of Tax Analysis of the Department of the Treasury, The Rand Corporation, Research Triangle Institute, Rice University, Rutgers University, Stanford University, Texas A & M University, Tilburg University CentER for Economic Research, University of Konstanz, University of Newcastle Upon Tyne, University of Texas-Austin, the U.K. Labour Economics Study Group, University of Oregon, and University of York for helpful comments. We are grateful for Deborah Garlow's expert proofreading and for financial support from the Office of the Vice President for Research and the University Graduate School of Indiana University, The Hoover Institution of Stanford University, and the Department of Economics of University College, London.

*Assistant Professor and Professor of Economics. Address communications to Thomas J. Kniesner, Dept. of Economics, Ballantine Hall (901), Indiana University, Bloomington, IN 47405-6620 USA; messages: (812) 855-1021; fax: (812) 855-3736; e-mail: Kniesne@Ophelia.UCS.Indiana.EDU

Abstract

We present an econometrically tractable life-cycle labor supply model to use with panel data that includes an intertemporally progressive tax on uncertain wage and nonwage incomes. We use a two-stage fixed-effects generalized method-of-moments approach to estimate first intratemporal and then intertemporal preferences parameters. Extensive specification testing demonstrates the need for panel data to incorporate joint taxation of labor and nonlabor incomes and the sensitivity of structural labor supply parameter estimates to modeling choices. Results for prime-aged men from the Panel Study of Income Dynamics show that the current wage (gross or net) is not exogenous, the researcher need include common year-specific effects as well as worker-specific effects, the parameter estimates are sensitive to how one measures the rate of pay, and the budget constraint is time nonseparable. In simulations of the labor supply and welfare effects of taxes we found that the tax reforms of the 1980s stimulated prime-age men's labor supplied by about three percent, reduced deadweight loss by about 16 percent, but were not self financing.

JEL Classification: J22

Key Words: labor supply, method of moments, nonlinear taxes, panel data, time nonseparability

1. Introduction

Consider the two strands of empirical labor supply research. The macroeconomic literature has focused on workers' willingness to substitute into and out of leisure as real wages fluctuate, which is crucial to understanding the cyclicality of hours worked and (un)employment (Kniesner and Goldsmith 1987). Micro labor supply research has as a main theme the work-incentive effects of transfers and taxes, including policies such as the Economic Recovery Tax Act of 1981 and the Tax Reform Act of 1986 (Moffitt 1992, Bosworth and Burtless 1992, Eissa 1995). A shortcoming in the empirical labor supply literature, micro and macro, is a lack of attention to the life-cycle effects of taxes and transfers. We extend the economic literature by using panel data to estimate intratemporal preferences parameters that interest micro economists and intertemporal preferences parameters that interest macro economists while examining the labor supply effects of intertemporally progressive joint taxation of wage and interest incomes.

The great leap forward in quantifying the labor supply effects of taxes came with econometric models acknowledging unobserved heterogeneity and measurement errors when the budget constraint is piecewise linear due to tax and transfer programs (Burtless and Hausman 1978, Hausman 1981a). Econometric models of labor supply including income taxes are still generally static and do not capture intertemporal effects of tax reforms. A substantive, but orthogonal, branch of empirical labor supply research has focused on intertemporal substitutability of labor while ignoring the influence of income taxes and transfers (Heckman and MaCurdy 1980, 1982; MaCurdy 1981, 1985; Altonji 1986; Mankiw, Rotemberg, and Summers 1985).[1] Incorporating the realism of interest

[1]MaCurdy (1983) is an exception to the generally separate research on life-cycle labor supply and research using the static model to estimate labor supply tax effects. MaCurdy ignored capital-income taxation, however, which is contrary to most countries' tax systems. Because he linearized the budget constraint while applying instrumental-variables estimation to the transformed, sometimes nonconvex, choice set MaCurdy's parameter estimates may also be inconsistent.

income taxation along with wage taxation complicates the econometric model because dual taxation generates time nonseparabilities in the budget constraint (Blomquist 1985).

A regularly appearing result in empirical research on labor supply, static or dynamic, including or ignoring wage taxation, is that intratemporal (un)compensated wage effects and intertemporal substitution effects are small and imprecisely estimated.[2] There is even little agreement on whether the estimated compensated wage effect is positive or if the Slutsky matrix conditions hold empirically (Killingsworth 1983, Pencavel 1986, Conway and Kniesner 1994). A positive (un)compensated wage effect means that moving to a flatter tax induces more hours worked and reduces deadweight loss while a negative (un)compensated wage effect produces economic effects opposite those usually intended by proponents of tax reform.[3] The lack of consensus on the magnitude and sign of compensated wage effects continues to muddy discussions of the welfare implications of a flatter tax structure (Hausman 1981a, Hall and Rabushka 1983, MaCurdy 1992).

Our research produces what we argue are improved estimates of the work incentive effects of progressive income taxation on life-cycle labor supply. We present a two-stage generalized method-of-moments econometric model that first estimates intratemporal wage effects from labor supply conditioned on asset positions at the beginning and end of the period. Instead of the usual piecewise-linear budget set we use a continuously differentiable smooth budget constraint to mitigate the problem of measurement errors created by incorrectly imputing the marginal tax rate (MaCurdy, Green, and Paarsch 1990; Flood and MaCurdy 1992). Moreover, maximum likelihood estimation (Burtless and Hausman 1978, Hausman 1981a) ensures satisfaction of the Slutsky condition, a positive wage effect, and a negative income effect, ruling out a downward sloping

---

[2]There are exceptions who found intertemporal substitution elasticities exceeding +1.0 by including a participation decision and higher than annual frequency data (Jakubson 1988, Rogerson and Rupert 1991, and Kimmel and Kniesner 1993).

[3]Negative substitution effects can appear, a priori, in a life-cycle model due to time nonseparabilities caused by nonlinear income taxes (Blomquist 1985).

estimated labor supply function on a priori statistical grounds (MaCurdy 1992). Perhaps most important from a practical standpoint, maximum likelihood estimation rests on the empirically untenable ground of an exogenous pre-tax wage. The instrumental-variables approach we take is more general because it permits a negative estimated uncompensated wage effect on labor supply and does not require gross wage rate exogeneity.

After obtaining consistent estimates of intratemporal labor supply behavior we then apply a second stage generalized method-of-moments estimator to the Euler condition for the marginal utility of net wealth to recover intertemporal preferences parameters underlying fluctuations in labor supply. We compute anticipated and unanticipated intertemporal labor supply wage elasticities with lifetime preferences parameters. Our estimates for prime-aged U.S. men contribute to both the micro and macro empirical labor supply literatures.

We find the following results of note. The compensated wage effect is sensitive to the wage measure and instrument set. There is evidence of time nonseparability in the budget constraint supporting the estimator we develop. Most importantly, our results support the need to use panel data and to incorporate the joint nonlinear taxation of wage and nonwage income in labor supply research. Simulations with our results indicate that recent U.S. tax reforms stimulated labor supplied, reduced deadweight loss, but were not self financing.

2. Life-Cycle Labor Supply with Joint Nonlinear Wage and Interest Income Taxes

A major innovation in estimating life-cycle labor supply has been to recognize that in an environment of economic certainty extra-period information can be summarized by a latent time-invariant worker-specific effect (λ, the marginal utility of wealth) so that the estimating equation needs only current period economic information (Heckman and MaCurdy 1980, 1982; MaCurdy 1981). In an environment of (un)certain wages and interest rates contemporaneous net dissaving ($\mu_t = r_t A_{t-1} - \Delta A_t$) is sufficient to summarize extra-period information, again simplifying estimation (MaCurdy 1983;

Blundell and Walker 1986; Blundell, Meghir, and Neves 1993). The empirical convenience of estimating labor supply functions conditioned on λ or μ_t is maintained when wage income is taxed (non)linearly or when wage and interest incomes are jointly taxed linearly. A theoretically valid econometric labor supply model becomes more complicated when wage and interest incomes are jointly taxed *non*linearly, as is true in most Western economies (Blomquist 1985).

To see the complications introduced by joint nonlinear taxation of labor and capital incomes consider a person who has preferences over consumption, C_t, and hours of paid work, h_t, ($t = 1 \ldots T$). Preferences over consumption and labor supply are defined by a strictly concave utility function, $U = U(C_t, h_t)$, and the choice set is given by a budget constraint, $g(C_t, h_t, r_t, W_t, T(I_t, \pi)) = 0$, where r_t and W_t are time vectors of real interest and real wage rates and $T(I_t, \pi)$ is a nonlinear tax function defined over the time vector of taxable income (I_t) and tax parameters (π). As Blomquist (1985, pp. 517–518) notes, if the researcher imposes no time separability properties on the lifetime utility function or budget constraint then a change in the wage rate in period *t* (W_t) will affect consumption and labor choices in period *t+1* through three channels: (i) it will tighten or slacken the budget constraint, which produces a wealth effect, (ii) it will alter C_t or h_t, which in turn alters the indifference curves between consumption and labor choices in the next period, *t+1*, and (iii) it will alter marginal prices and wages in period *t+1*, which is due to nonlinear income taxation.

Imposing intertemporal separability on the lifetime utility function eliminates the intertemporal preferences effect of a change in wages, channel (ii), and imposing intertemporal separability in the budget constraint by, say, linear taxes, $T(I_t, \pi) = \pi I_t$, eliminates the intertemporal marginal price effect, channel (iii), so that intertemporal separability of lifetime preferences and the budget constraint means that a change in the current wage rate, W_t, has only a wealth effect on future labor supply, h_{t+1}. The first-order condition for an interior maximum of hours worked under intertemporal separability in preferences and budgets is

$$\frac{\partial U}{\partial h_t}=\frac{w_t}{w_{t+1}}\frac{1+r_{t+1}(1-\pi)}{1+\rho}\frac{\partial U}{\partial h_{t+1}}, \qquad (1)$$

where ρ is the subjective discount rate. The first-order condition under joint separability permits one to write labor supply in an environment of economic certainty as a function of λ, W, and π, $h_t = h(W_t(1-\pi),\lambda)$, or in an economic environment of uncertainty as a function of μ, W, and π, $h_t = h(W_t(1-\pi),\mu_t)$; that is, the marginal utility of wealth or dissaving function as sufficient statistics for extra-period (typically unmeasured) information.

If, however, the researcher allows a realistically progressive tax function over wage and interest incomes then current wage changes will affect the future net wage and interest rates (channel (iii)) so that a change in W_t will have both wealth and substitution effects on h_{t+1}.[4] In particular, the first-order conditions under joint nonlinear taxation are

$$\frac{\partial U}{\partial h_t}=\frac{W_t[1-T'(I_t)][1+r_{t+1}(1-T'(I_{t+1}))]}{W_{t+1}[1-T'(I_{t+1})][1+\rho]}\frac{\partial U}{\partial h_{t+1}}, \qquad (2)$$

where $T'(I_t)$ is the marginal tax rate evaluated at period t income. Unlike the linear tax case the after-tax interest rate is now endogenous with labor supply in both periods t and $t+1$. Moreover, period t labor supply is now a function of the marginal utility of wealth, the real after-tax wage in period t, and the discounted after-tax wage in period $t+1$ so that $h_t = h(W_t(1-T'(I_t)),\hat{W}_{t+1}(1-T'(\hat{I}_{t+1})),\lambda)$. Unless one is willing to assume knowledge of future wages, prices, taxes, and interest rates the λ-constant labor supply specification will not be of much practical use when there is joint nonlinear taxation.

However, Blomquist (1985) notes that under two-stage budgeting it is still possible to estimate consistently the intratemporal utility parameters by replacing the sufficient net dissaving statistic μ_t with beginning-of-period assets (A_{t-1}) and end-of-period assets

---

[4]Note that imposing intertemporal separability on the budget constraint but allowing intertemporally nonseparable preferences, perhaps via rational habit formation, leads to models found in Hotz, Kydland, and Sedlacek (1988) and Bover (1991).

(A_t), where starting assets (A_{t-1}) captures the influence of past decisions (Blundell and Walker 1986, p. 543) and ending assets (A_t) captures the influence of next period's prices. Contemporaneous net dissaving (μ_t) is no longer a sufficient statistic on its own for extra-period information because dissaving only permits future prices to have a wealth effect rather than both the wealth and substitution effects from joint nonlinear taxation. Finally, because Blomquist was unconcerned with intertemporal identification he did not note that the second stage, estimating intertemporal preferences via the Euler equation for the evolution of the marginal utility of net wealth, must also be modified for conditioning on current and lagged assets in the first step of estimation. The two-step model we employ conditions both estimating equations, the labor supply and Euler equations, on current and lagged assets.

2.1 The Indirect Utility Function

We begin with the indirect utility function[5]

$$\{[V_t(\omega_t, A_t, A_{t-1}; \Lambda)]^{(1+\sigma_t)} - 1\} / (1+\sigma_t), \tag{3}$$

where $V_t(\bullet)$ is a monotonically increasing function of the net real wage (ω_t) and assets (A_t and A_{t-1}) conditioned on the vector of intratemporal preferences parameters (Λ); $\sigma_t = \sigma_0 + \sum_k \sigma_k Z_{kt}$ are time varying intertemporal preferences parameters measuring risk aversion with Z a set of observable demographics (MaCurdy 1983; Browning 1986; Blundell, Fry, and Meghir 1990). The intertemporal preferences parameters, σ_t, determine the allocation of income and saving over time (Blundell, Fry, and Meghir 1990). Our two-step process first estimates the intratemporal preferences parameters, Λ, then uses $\hat{\Lambda}$ to estimate the intertemporal preferences parameters, σ_t, which are needed to compute life-cycle labor supply elasticities. Specifically, in the first stage we estimate a labor supply function conditioned on asset accumulation and in the second stage estimate the Euler equation for the path of the marginal utility of net wealth. A two-step approach

[5]The indirect utility function is a preferred starting point because of limited consumption information in our data set.

is needed because only intratemporal preferences parameters, Λ, in the indirect utility function in (3), are identifiable from the labor supply schedule we estimate in step one.

2.2 A Life-Cycle Consistent Labor Supply Function

To facilitate comparisons to the seminal econometric research on labor supply tax effects we purposely selected the indirect utility function underlying the popular linear labor supply function to estimate intratemporal preferences (Burtless and Hausman 1978; Hausman 1981a).[6] If h_t^* denotes a worker's desired labor supply

$$h_t^* = \alpha\omega_t + \delta A_{t-1} + \phi A_t + X_t\gamma\,, \tag{4}$$

where X_t is a vector of fixed and time-varying demographics affecting intratemporal preferences for work, and $\Lambda \equiv [\alpha, \delta, \phi, \gamma]'$ are estimated intratemporal preferences parameters we used in estimating the marginal utility of wealth equation. Current and lagged assets, A_{t-1} and A_t, are sufficient statistics for capturing extra-period information in our two-stage budgeting model with joint nonlinear wage and capital income taxation (as is also S_t together with $r_t A_{t-1}$ as Blomquist (1985) notes). Equation (4) has been termed a life-cycle consistent labor supply function (Blundell and Walker 1986).[7]

2.3 Marginal Utility of Net Wealth

Under the assumption of rational expectations and joint wage and interest income taxes the marginal utility of net wealth is

$$\beta[(1 + r_{n,t+1})\lambda_{A_{t+1}}] = \lambda_{A_t}\varepsilon_{t+1}\,, \tag{5}$$

---

[6] $V_t(\bullet) = e^{\delta\omega_t}[A_{t-1} + (\alpha\omega_t/2\delta) - (\alpha/2\delta^2) + (X_t\gamma/2\delta)] + e^{\phi\omega_t}[A_t + (\alpha\omega_t/2\phi) - (\alpha/2\phi^2) + (X_t\gamma/2\phi)]$. The linear labor supply function in (4) comes from application of Roy's Identity first with respect to ω_t and A_{t-1} then with respect to ω_t and A_t, or $h_t^* = [(\partial V_t/\partial\omega_t)/(\partial V_t/\partial A_{t-1}) + (\partial V_t/\partial\omega_t)/(\partial V_t/\partial A_t)]$. Although the two-stage budgeting approach we adopt does not constrain the functional form of intratemporal preferences, estimating the indirect utility function quickly becomes intractable with more flexible functional forms. See Stern (1986) for a useful discussion of alternative functional forms for labor supply and the associated (in)direct utility function.

[7] In the interest of completeness we note for the reader that (4) has also been labeled in the literature pseudo-Marshallian labor supply, intratemporal labor supply, within-period labor supply, intratemporal preferences equation, and within-period preferences equation.

where $\beta \equiv (1+\rho)^{-1}$ is the subjective discount factor, $r_{n,t+1} \equiv (1-\tau_{t+1})r_{t+1}$ is the after-tax (net) real interest rate, and ε_{t+1} is the forecast error between $(1+r_{n,t+1})\lambda_{A_{t+1}}$ and its expectation at time t. Taking natural logs, first differencing (5), and applying the marginal utility of net wealth from the indirect utility function (3) the stochastic equation we use to estimate intertemporal preferences is

$$\sigma_0 \Delta \ln \hat{V}_{t+1} + \sum_k \sigma_k \Delta(Z_{k,t+1} \ln \hat{V}_{t+1}) + \Delta \ln \hat{V}'_{t+1} + \kappa_{t+1} = \ln \varepsilon_{t+1}, \tag{6}$$

where $\Delta \ln \hat{V}_{t+1} = \ln \hat{V}_{t+1} - \ln \hat{V}_t$, $\Delta \ln \hat{V}'_{t+1} = \ln(\partial \hat{V}_{t+1} / \partial A_{t+1}) - \ln(\partial \hat{V}_t / \partial A_t)$, and $\kappa_{t+1} = r_{n,t+1} - \rho$ (Blomquist 1985; Blundell, Meghir, and Neves 1993).

3. Econometric Background

Cross-section data are sufficient to identify intratemporal preferences parameters, Λ. Identifying both intratemporal and intertemporal preferences requires either longitudinal or repeated cross-section data. Panel data also facilitate modeling unobserved worker heterogeneity. Our sequential two-step econometric approach is first to estimate labor supply conditioned on the starting and ending assets positions via equation (4). We then substitute the estimated intratemporal preferences parameters into the marginal utility of net wealth (6), treating first-stage parameter estimates as known constants. Finally, we apply a consistently estimated asymptotic covariance matrix for sequential generalized method-of-moments (GMM) estimators to correct for the fact that the standard errors of the second-stage Euler equation (6) depend on first-stage standard errors (Newey 1984).

3.1 Step One: Estimating Intratemporal Preferences

In our first stage we allow the life-cycle consistent labor supply estimating equation to include possible worker-specific latent heterogeneity

$$h_t = \alpha\omega_t + \delta A_{t-1} + \phi A_t + X_t\gamma + \eta_i + \xi_t, \tag{7}$$

where ξ_t is random error in hours worked at time t, which is assumed to be distributed as iid $(0,\sigma_\xi^2)$. We treat the net wage and assets as endogenous because the marginal tax rate depends on contemporaneous hours worked via earnings. Most importantly, the time-invariant worker-specific labor supply heterogeneity, η_i, is generally not independent of the regressors because life-cycle wealth has person-specific influences. A common econometric approach for handling endogenous worker heterogeneity is as a nonstochastic (fixed) effect. A popular econometric model for fixed effects is the within estimator. A within estimator is inconsistent in a labor supply equation conditioned on the net wage and lagged and current assets (7); the deviations from the individual time-series means used as regressors in the within estimator will not be independent of the overall labor supply errors, ξ_t, because the tax rate depends on current hours worked. The first-differences estimator we apply to labor supply (7) is consistent for a two-stage rational expectations model such as ours (Keane and Runkle 1992).

The GMM Estimator. Define the function $g(P,D;\Lambda)$ as

$$g(P,D;\Lambda) = D'(\Delta h - P\Lambda) \equiv D'\xi, \tag{8}$$

where $P \equiv [\Delta w_t, \Delta A_{t-1}, \Delta A_t, \Delta X_t]$ is the $(N(T-1) \times L)$ matrix of first-differenced regressors in the estimated labor supply function in (7), D is an $(N(T-1) \times K)$ matrix of instruments dated $t-1$ and earlier, Δh is the $(N(T-1) \times 1)$ vector of first-differenced hours worked, and Λ contains $(L \times 1)$ intratemporal preferences parameters to be estimated, $[\alpha, \delta, \phi, \gamma]'$.

The criterion function we minimize is

$$J_T(\Lambda) = g(P,D;\Lambda)' S_{gg}^{-1} g(P,D;\Lambda), \tag{9}$$

where S_{gg} is an optimal weighting matrix, $(D'E(\Delta\xi\Delta\xi')D)$. Initial consistent estimates for the vector $\Delta\xi$ come from a consistent but sub-optimal weighting matrix, the identity matrix. Solving the criterion function for the feasible generalized method-of-moments estimator gives

$$\hat{\Lambda} = [P'D\hat{S}_{gg}^{-1}D'P]^{-1} P'D\hat{S}_{gg}^{-1}D'\Delta h, \tag{10}$$

which has the estimated asymptotic covariance matrix

$$Var(\hat{\Lambda}) = [P'D\hat{S}_{gg}^{-1}D'P]^{-1}. \tag{11}$$

Estimating labor supply via (8)–(10) in first differences due to latent heterogeneity and rational expectations creates an MA(1) process in the transformed random disturbance, $\xi_t - \xi_{t-1}$, which influences the functional form of the weighting matrix, S_{gg} (Maeshiro and Vali 1988). The weighting matrix in our GMM first-differences model, $\hat{S}_{gg}$, is the sum of a conditionally heteroskedastic matrix ($\hat{\Omega}_0$) and an autocorrelation matrix ($\hat{\Omega}_1$) such that

$$\hat{S}_{gg} = \hat{\Omega}_0 + [\hat{\Omega}_0 + \hat{\Omega}_1'], \tag{12}$$

where

$$\hat{\Omega}_0 = (1/N(T-1))\sum_i \sum_t (D_{it}' \Delta\hat{\xi}_{it} \Delta\hat{\xi}_{it}' D_{it}), \tag{13}$$

$$\hat{\Omega}_1 = (1/N(T-1))\sum_i \sum_t (D_{it}' \Delta\hat{\xi}_{it} \Delta\hat{\xi}_{it-1}' D_{it-1}), \tag{14}$$

$i = 1,\ldots,N$, and $t = 1,\ldots,T-1$.[8] Predetermined information dated $t-2$ and earlier can be instruments in light of the MA(1) errors in the first-differenced life-cycle consistent labor supply (Griliches and Hausman 1986).

In addition to testing over-identifying restrictions some other specification tests are prudent in step one. Motivated by previous research that has generally conditioned hours worked on only concurrent asset income or net (dis)saving, an obvious specification test is a likelihood-ratio test of whether the additional lagged wealth term (A_{t-1}) is statistically significant in the estimated first-stage labor supply function. Specifically, we compare $J_T(\hat{\Lambda})$ in the unrestricted labor supply model (7) to $J_T(\hat{\Lambda}')$ in a restricted model that conditions hours worked on the net wage and current virtual saving using the statistic

$$LR = T[J_T(\hat{\Lambda}') - J_T(\hat{\Lambda})] \sim \chi_S^2. \tag{15}$$

The degrees of freedom in the chi-squared statistic, S, is the number of restrictions imposed (Newey and West 1987a). Because it is possible for the restricted criterion function to be less than the unrestricted criterion function the test of the significance of

[8]When the weighting matrix is not positive semidefinite we use a method of modified Bartlett weights (Newey and West 1987b). We do not confront the additional complexity that possible measurement errors can introduce nonlinear random errors into the estimated indirect utility function, requiring a nonlinear errors-in-variables estimator in step two. Developing an instrumental variables estimator for nonlinear errors in the variables of our step two indirect utility function is beyond the scope of our research. For examples of nonlinear errors in variables models see Amemiya (1985, 1990) and Hsiao (1989).

the labor supply effect of lagged assets is asymptotically consistent in the positive semidefinite sense if one uses the unrestricted weighting matrix ($\hat{S}_{gg}$) in both minimizations.

Our third specification test, which takes the same form as the likelihood-ratio test statistic in (15), is a Hausman-type (exogeneity) test of the validity of the contemporaneous gross wage rate as an instrument (Newey 1985). Remember that exogeneity of the gross wage is a necessary condition for consistent estimation of labor supply with taxes via maximum likelihood. Rejecting gross wage exogeneity tells the researcher to avoid the maximum-likelihood estimator popularized by Burtless and Hausman (1978) and to follow instead an instrumental-variables approach such as we do.

3.2 Step Two: Estimating Intertemporal Preferences

In step two we estimated intertemporal preferences parameters. The Euler equation for the motion in the marginal utility of net wealth (6) defines the GMM criterion function for our second step estimates that is

$$m(P,Z,M;\hat{\Lambda},\Theta) \equiv M'[\sigma_0 \Delta \ln \hat{V}_{t+1} + \sum_k \sigma_k \Delta(Z_{k,t+1} \ln \hat{V}_{t+1}) + \Delta \ln \hat{V}'_{t+1} + \kappa_{t+1}]. \quad (16)$$

In the criterion equation (16) M is an ($N(T-2) \times Q$) matrix of instruments, Θ is the ($K \times 1$) vector of intertemporal preferences parameters we estimate. The step two criterion function we then minimize is

$$J_T(\Theta;\hat{\Lambda}) = m(P,Z,M;\hat{\Lambda},\Theta)'\hat{S}_{mm}^{-1} m(P,Z,M;\hat{\Lambda},\Theta), \quad (17)$$

where the weighting matrix in the criterion function (17), $\hat{S}_{mm} \equiv (M'(\ln \hat{\varepsilon}_{t+1} \ln \hat{\varepsilon}'_{t+1})M)$, is conditionally heteroskedastic. We obtain initial consistent estimates of the random disturbance, $\ln \varepsilon_{t+1}$, by setting the weighting matrix equal to the identity matrix.

Standard errors for the estimator of intertemporal preferences Θ may be inconsistent because they depend on first-stage standard errors. We use a consistently estimated asymptotic covariance matrix of $\hat{\Theta}$ that is

$$\hat{\Omega}_{\Theta} = [m_{\Theta}' \hat{S}_{mm}^{-1} m_{\Theta}]^{-1} + [m_{\Theta}' m_{\Lambda}^{-1} (Var(\hat{\Lambda}))^{-1} m_{\Lambda}^{-1'} m_{\Theta}]^{-1}$$
$$-[m_{\Theta}' [m_{\Lambda} g_{\Lambda}^{-1} \hat{S}_{gm} + \hat{S}_{mg} g_{\Lambda}^{-1'} m_{\Lambda}']^{-1} m_{\Theta}]^{-1}, \tag{18}$$

where m_{Θ}, m_{Λ}, and g_{Λ} are partial derivatives, and $\hat{S}_{mg}$ is the sample covariance between $g(\bullet)$ and $m(\bullet)$ to correct for potential bias in the second-stage standard errors of estimated intertemporal preferences (Newey 1984).

3.3 Parameterizing Taxes

The most influential econometric research on labor supply tax effects has applied maximum likelihood to incorporate the piecewise-linear budget constraint (Burtless and Hausman 1978; Hausman 1980, 1981a). Maximum likelihood rests on strong behavioral assumptions: that a worker has complete knowledge of all tax brackets ex ante, that the gross wage and gross nonwage income are exogenous to labor supply, and that the Slutsky condition is satisfied at all internal kink points of the budget constraint.

Exogeneity of the gross wage is unlikely, especially because the gross wage researchers have used most often has been average hourly earnings. If hours worked are measured with error then so is average hourly earnings, which then must be treated as endogenous, violating an assumption of maximum likelihood. To ensure positive probabilities and a well-behaved likelihood function maximum likelihood also regulates the allowable set of labor supply responses, forcing a nonnegative estimated wage effect and a nonpositive estimated asset income effect (MaCurdy, Green, and Paarsch 1990; Flood and MaCurdy 1992; MaCurdy 1992). Because of its econometric complexity and the stringent ex ante restrictions maximum likelihood places on estimated labor supply parameters an alternative estimator such as the instrumental-variables approach we use is attractive.

Differentiable Marginal Tax Rate. Because our estimator requires only information on the effective marginal tax rate it substantially eases the computation burden. Specifically, because reported taxable income is relatively free of measurement error in the typical micro data set the marginal tax rate can be closely tracked by a differentiable polynomial in taxable income (MaCurdy, Green, and Paarsch 1990; Rodgers, Brown, and Duncan 1993). A differentiable marginal rate can also be integrated back to infer the total taxes function needed to construct net wealth.

A differentiable marginal tax rate approach to parameterizing net wages and nonwage income easily accommodates the fact that social security taxes apply only to a portion of earnings. Moreover, during our sample period most states had progressive income-tax schedules where about three-fourths of the states used federal adjusted gross income or federal taxable income as their bases. We judge the impact of state taxes as too important to ignore while too complicated to represent exhaustively. Because we focus on how federal income taxes affect life-cycle labor supply we augment the worker's federal marginal tax and social security tax rates with an average state tax rate defined as the ratio of individual state income tax collections to adjusted gross income in the state.

Algebraically, we adopt the total marginal tax rate specification

$$\tau_t = [\Phi_{1t} - \Phi_{2t}]\tau_{st} + [\Phi_{2t} - \Phi_{3t}]b(I_t) + \Phi_{3t}\tilde{\tau}_t + \Phi_{sst}\tau_{sst}, \tag{19}$$

where τ_{st} is the average state tax rate, $b(I_t)$ is an estimated polynomial in taxable income (I_t), $\tilde{\tau} = \tau_{st} + \tau_{ut}$ with τ_{ut} the top federal marginal tax rate in year t, and τ_{sst} is the payroll tax rate (MaCurdy, Green, and Paarsch 1990). In the marginal tax rate in (19) $\Phi_{jt}[(I_t - \mu_{jt})/\sigma_{jt}]$ $(j = 1,2,3)$ is the cumulative distribution function for the standard normal where Φ_{jt} is pseudo-spline function equal to 1 when $I_t \geq \mu_{jt}$ and equal to zero when $I_t < \mu_{jt}$. The speed at which a worker switches from one marginal tax bracket to another is determined by σ_{kt}, with greater smoothness produced by larger values of σ_{kt}. The parallel pseudo-spline function for social security taxes is $\Phi_{sst}[(\mu_{sst} - Y_t)/\sigma_{sst}]$, where μ_{sst} is the cutoff for the social security tax base, and Y_t is labor earnings. A worker's marginal tax rate is then the state income tax rate, τ_{st}, plus the federal marginal tax rate and the social security tax rate when nonzero.

The polynomial $b(I_t)$ in the tax function (19) approximates all of the marginal tax brackets within a given range. In 1978, for example, there are 15 marginal tax brackets between taxable incomes of $3200 and $67,200. Taking $50 increments in incomes $3200 to $67,200 and calculating the associated statutory marginal tax rates in 1978 yields 1280 pairs of incomes and marginal tax rates. The cubic ordinary least squares regression we ran through the 1280 marginal tax rate-income pairs to summarize the 1978 federal tax table for married couples filing jointly is

$$b(I_t) = \tau_{st} + 0.0402 + (1.4410^{-5})I_t - (1.2110^{-10})I_t^2 + (2.4910^{-16})I_t^3. \quad \textbf{(20)}$$

Figure 1 illustrates how well the smooth tax function replicates the federal income tax schedule exclusive of the average state and social security tax rates.[9] [Insert Figure 1 here.]

The first year of our sample, 1978, provides an example of how the marginal tax function (19) operates for a married couple filing jointly.[10] The first term in the tax function (19) reflects the zero bracket amount in the tax schedule. For taxable income above zero but less than $3200 $\Phi_{1t} \cong 1$, $\Phi_{2t} \cong 0$, $\Phi_{3t} \cong 0$, $\Phi_{sst} = 1$, and the marginal tax rate is the state tax rate plus the payroll tax rate of 6.05 percent. When taxable income reaches $3200 $\Phi_{2t} = 1$, making the first term in (19) zero but adding the second term so that the worker faced the marginal tax rate implied by the polynomial $b(I_t)$ in (20). When taxable income reaches $67,200 $\Phi_{3t} = 1$, the second term in (19) vanishes, and the effective marginal tax rate is the 1978 maximum federal rate of 55 percent, the state income tax rate, plus the payroll tax rate if gross labor earnings were below $17,000.

4. Data

Our data are for 1978–1987 from the Panel Study of Income Dynamics, which is the data set used most frequently to study U.S. labor supply. The PSID is also the data from

---

[9] $R^2 = 0.98$.

[10] We set the standard deviation, σ_{jt}, to 0.2 for each segment j, which provides an adequate degree of curvature to the tax function according to MaCurdy, Green, and Paarsch (1990).

which much influential U.S. research on taxes and labor supply has drawn its samples (Hausman 1981a; MaCurdy, Green, and Paarsch 1990), making comparisons to our results maximally informative. We selected our sample using multidimensional rules similar to others studying prime-aged male labor supply. Our sample is continuously married, continuously working men who were ages 22 to 51 in 1978. The worker must have been paid either an hourly wage rate or a salary; we deleted piece-rate workers and the self employed. Our selection process yielded a balanced panel of 532 prime-aged U.S. men over 10 years, for 5320 person years of observations. The Appendix contains summary statistics for all variables used in estimation.

4.1 Wages

The Panel Study of Income Dynamics asks all workers how they are paid. For workers paid by the hour the gross hourly wage rate is recorded. The interviewer asks workers paid salaries how frequently they are paid, such as weekly, bi-weekly, or monthly. The interviewer then norms a salaried worker's pay by a fixed number of hours depending on the pay period. For example, salary divided by 40 is the hourly wage rate constructed for a salaried worker paid weekly. The gross hourly wage rate we use is as free as possible of the division bias found in labor supply regressions using average hourly earnings as the wage.[11]

4.2 Taxable Income

When constructing annual taxable income we assumed that the married men in our sample filed joint tax returns. 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 (dependents) taken in each year but calculating deductions required some effort on our part.

---

[11] For evidence on how the gross wage measure affects labor supply parameter estimates see Conway and Kniesner (1992, 1994).

Computing the value of deductions depends on the year under consideration. To evaluate deductions for years prior to and including 1983 we followed the convention established in the PSID. With information from the Internal Revenue Service's *Statistics of Income* we generated the typical value of itemized deductions based on the man's adjusted gross income. We then calculated the difference between typical itemized deductions and the standard deduction, known as excess itemized deductions. When excess itemized deductions were positive we subtracted it from adjusted gross income; when excess itemized deductions were not positive we applied the standard deduction for the years prior to and including 1983.

Beginning in 1984 the PSID records whether the family itemized. For known itemizers we subtracted excess itemized deductions from adjusted gross income and used the standard deduction for the men who did not itemize deductions for 1984 and thereafter. One other small detail. 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 came into effect the standard deduction is no longer built into the tax tables so we subtracted either the standard deduction or total itemized deductions from adjusted gross income depending on whether the family itemized or not.

4.3 Assets

The Panel Study of Income Dynamics has little information on interest rates, assets, and saving. In estimating the Euler equation for the marginal utility of net wealth (6) we use the after-tax annual average three-month T-Bill interest rate. We constructed assets as the sum of the liquid and illiquid asset measures in the PSID. Liquid assets are nominal rent, interest, and dividend income capitalized by a nominal interest rate. We capitalized the first $200 of income from liquid assets by the annual average passbook savings account rate and capitalized rental income in excess of $200 per year by the annual average three-month T-Bill rate. For the illiquid component of assets we used the value of home equity defined as the difference between house value and outstanding principal remaining. Unlike previous researchers (Zeldes 1989, Runkle 1991) we included illiquid assets because more wealth resides in home equity than in other liquid components.[12] In our sample almost 90 percent of the men are homeowners, but just over half the men have liquid wealth. Because workers do not face their marginal tax rates for all taxable income we added a capitalized lump-sum transfer to lagged wealth (A_{t-1}), creating virtual wealth. We adjusted lagged wealth because A_{t-1} enters the current period's tax function. Our virtual wealth is a life-cycle model's analog to virtual income in the static model of labor supply with income taxes.[13]

5. Econometric Results

Our econometric approach first estimates life-cycle consistent labor supply functions to identify intratemporal preferences. In the course of our first step we address a number of specification issues we believe have received insufficient attention. Specifically, in step one we examine whether the current wage (gross and net) is exogenous, whether the researcher need include common year-specific effects as well as worker-specific effects, whether the parameter estimates are sensitive to how one measures the rate of pay, and whether the budget constraint is time (non)separable. In step two we estimate intertemporal preference parameters conditional on the econometrically dominant intratemporal preference parameters estimated in step one. When estimating the intertemporal preferences in step two via the intertemporal Euler equation we are again

---

[12]The PSID collected comprehensive wealth data in 1984 and 1989, including data on house equity, net value of other real estate, net value of vehicles, net value of a farm or other business, and net value of other assets. The measure of total wealth from the PSID has been used by others (Hubbard, Skinner, and Zeldes 1994, 1995). Ziliak (1994) demonstrates that variation in our measure of liquid wealth explains about half the variation in total wealth while including home equity makes variation in our measure of wealth explain 80 percent of total wealth. The ability of our wealth measure to track total wealth when measured independently is our justification for including both liquid and illiquid wealth measures in our definition of wealth. Our summary wealth statistics are comparable to wealth measures from the Survey of Income and Program Participation (Engen, Gale, and Scholz 1994).

[13]Virtual wealth is the sum of lagged wealth plus the capitalized value of the lump-sum transfer so that virtual wealth is $A_{t-1} + [(\tau(I_t) - T(I_t)/I_t) * I_t]/r_t$ where r_t is the nominal annual average of the 3-month T-bill rate. In all regressions in Table 2 we use net saving plus the uncapitalized lump-sum transfer.

interested in the importance of possible economy-wide shocks as well as possible person-specific discount rate heterogeneity. Part of step two is a test of the underlying rational expectations hypothesis using an ancillary equation for updating the marginal utility of net wealth. Finally, we use our estimates of intra and intertemporal preferences for prime-age men to compute the lifetime indirect utility function plus the wage and tax elasticities of labor supply with respect to transitory versus permanent and expected versus unexpected net real wage changes. Our indirect utility function and labor supply elasticity estimates are the foundation of simulations of the behavioral responses to and welfare effects of recent U.S. tax policies in Section 6.

5.1 Step One: Estimating Intratemporal Preferences

We estimate intratemporal preferences using equation (7), life-cycle consistent labor supply with worker-specific heterogeneity. All regressions condition on demographics usually included in econometric models of labor supplied — age, health status, and number of children living at home. As explained in Section 3 our maintained hypothesis of rational expectations leads us to an approach common in estimation with panel data when there are worker-specific fixed effects, the first-difference transformation.

We generate initial parameter estimates by choosing the identity matrix as the initial weighting matrix, which is a consistent instrumental-variables estimator. Residuals from initial IV regressions form the weighting matrix for GMM estimates.

Basic Instrument Set. The instrument sets for estimating intratemporal preferences in step one date $t-1$ and $t-2$. There are 20 instruments in the basic instrument set in step one: a constant; values at $t-1$ and $t-2$ of age, age^2, (age∗education), number of children, health status (= 1 if disabled), union status (= 1 if member), and home ownership; and values at $t-2$ of the gross real wage, the net real wage, the net three-month T-Bill rate, net real wealth, and net real virtual wealth.

We chose our instruments for all steps of estimation based on multiple criteria. One requirement was parsimony and similarity to previous empirical labor supply research.

More important is that instruments must all be exogenous, which we verified with an *LR* test. We did not, however, use the largest possible instrument set by exploiting extreme nonlinearities or all possible moment conditions as discussed in Ahn, Lee, and Schmidt (1994). We also did not attempt to choose an instrument set that maximizes a measure of fit between instruments and the set of endogenous regressors or maximizes efficiency conditional on consistency as discussed in Hall (1993) and Newey and McFadden (1994).

Specification Checks. We examine the econometric consequences of how one measures the wage rate by running parallel specifications using average hourly earnings versus the reported hourly wage. We use a Hausman-type testing approach to the issue of the exogeneity of the current gross wage by running regressions with and without the current gross wage in the instrument set. Finally, we also estimate regressions where we append time (year-specific) dummy variables to the basic instrument set because the validity of time dummies is important for the consistency of GMM estimation in rational expectations models because year-specific effects will capture forecast errors from common economy-wide disturbances (Chamberlain 1984, p. 1311).

Table 1 presents six fixed-effects labor supply estimates conditioning on current and lagged assets, and Table 2 presents six fixed-effects labor supply regressions conditioning on current virtual saving. Comparisons of regressions across the columns within either Table 1 or Table 2 indicate the econometric consequences of (1) possible economy-wide forecast errors, (2) the wage measure, and (3) nonexogeneity of the current gross wage. The difference between results in Tables 1 and 2 reveals time (non)separability in the lifetime budget constraint. [Insert Tables 1 and 2 here.]

Step One Results. Important for how best to estimate labor supply tax effects is the change in the estimated wage coefficient when we appended the contemporaneous gross hourly wage to the instrument set. Both the uncompensated and compensated wage elasticities are significantly negative in column (2) of Table 1 suggesting downward-sloping uncompensated and compensated labor supply schedules, which violates the Slutsky integrability conditions. Because the *p*-value for the *LR* test comparing the regressions in columns (1) and (2) of Table 1 is 0.015 the data reject the extra over-identifying restriction imposed by adding the gross wage to the instrument set in what we will emphasize is the preferred case of the observed hourly wage regressor. (Similarly, the data reject the validity of the current gross wage as an instrument with a *p*-value of 0.008 in the case of the expanded instrument set with time dummies.) Rejecting the contemporaneous gross wage as a valid instrument supports our instrumental-variables approach to estimation over maximum likelihood, which requires gross wage rate exogeneity.[14]

Both current and lagged assets have estimated coefficients producing negative labor supply wealth effects in Table 1. However, the estimated (un)compensated labor supply wage effect is significantly positive only when the instrument set correctly includes time dummies ($p = 0.088$), properly excludes the contemporaneous gross wage, and uses as the wage the more accurately measured reported hourly rate of pay. The corresponding estimated marginal tax elasticity in column (3) of Table 1, found by differentiating the labor supply function with respect to the marginal tax rate, is negative so that hours of work decline with increases in marginal tax rates. Recall that a finding common in the static labor supply literature is a downward sloping or vertical uncompensated labor supply function for men, possibly due to using average hourly earnings as the wage regressor (Conway and Kniesner 1992, 1994), which is the case in the results presented in columns 4–6. Not only does the more negative estimated coefficient of average hourly

---

[14]Appending the contemporaneous gross average hourly earnings to the instrument set in column (4) of Table 1 has less effect on the estimated wage coefficient because the wage elasticities are insignificantly negative. Comparing the *J*-statistics of columns (4) and (5) highlights the problem noted by Newey and West (1987a) that the restricted model may have a lower computed *J*-statistic. Using the unrestricted covariance matrix with restricted residuals and common instruments yields a *LR* test statistic of 4.11 with a *p*-value of 0.043 at one degree of freedom, suggesting a weaker rejection of the concurrent gross average hourly earnings as a valid instrument. With time dummies in the instrument set the *LR* test statistic for rejecting gross average hourly earnings exogeneity is 335.76 ($p = 0.000$). For completeness we also note that the data reject exogeneity of the current *net* wage with, for example, a *p*-value of 0.004 in the case of the reported hourly wage and time dummies in the instrument set in Table 1.

earnings in Table 1 suggest wage coefficient division bias (Borjas 1980), but the goodness-of-fit (J) statistic also favors the model with the reported wage in column (3) of Table 1 over the regression model with average hourly earnings in column (6).

As brought out in Section 2 a time-separable life-cycle labor supply model may condition hours worked on current net saving. Table 2 presents analog labor supply regressions to Table 1 collapsing current and lagged assets into net virtual saving, $S_t \equiv A_t - (1+r_{nt})A_{t-1} + L_t$, where L_t is the lump-sum transfer needed to create virtual saving ($L_t \equiv [(\tau(I_t) - T(I_t)/I_t)*I_t]$), which is a sufficient statistic for extra-sample period information under time separability (MaCurdy 1983; Blundell, Meghir, and Neves 1993). Unlike Table 1 the estimated wage coefficient is negative in Table 2 whether the gross wage or time dummies are excluded from (included in) the instrument set for the reported hourly wage.[15] The net saving coefficient has the ex ante expected negative sign in Table 2. The overidentifying restrictions do not favor the models using time dummies as instruments in Table 2, which may reflect the fact that net saving does not adequately capture aggregate shocks to labor supply while the model in Table 1 does.

Perhaps most important for step two to follow is that the intertemporally nonseparable model in column (3) of Table 1, life-cycle consistent labor supply estimated with the reported wage and including time dummies but omitting the gross wage from the instrument set, econometrically dominates (is not rejected in favor of) the time-separable models in Table 2. In particular, no regression model in Table 2 has the jointly required significantly negative saving effect and significantly positive compensated wage effect. From tests of instrument exogeneity and intertemporal nonseparability ($LR = 9.845$ with $p = 0.002$ for rejection of the null hypothesis that budgets are time separable) we select

[15]The negative wage coefficient in the net saving models appears under a variety of instrument set choices including instrument sets without lagged endogenous variables (containing only demographics). The suboptimal 2SLS wage coefficient is positive and insignificant. The difference between (untabulated) 2SLS coefficients and the GMM results in Table 2 can stem from a negative correlation between the weight matrix and the regressors (Altonji and Segal 1994). A possible downward bias due to a correlation between the weight matrix and regressors does not occur in the GMM nonseparable models in Table 1.

column (3) of Table 1 for the estimated labor supply parameters to use in step two regressions and in the simulations of Section 6 calculating the labor market and welfare effects of recent tax regime changes.

Quality of the Instrument Set. An important line of recent econometric research has been to examine IV estimation when the instruments are weakly related to the associated endogenous explanatory variable. The two consequences of weak instruments (for example, $R^2 \leq 0.05$ between a single explanatory variable and the instruments) are large inconsistencies in IV parameter estimates even if the correlation between the instruments and the structural equation error is small and IV parameter estimates that are biased in the direction of OLS even in large samples (Bound, Jaeger, and Baker 1995). The practical implication is that when applying instrumental variable estimation one should not only test whether the over-identifying restrictions hold but also examine and report information summarizing the strength of the instrument set. In a case such as our GMM approach where there is a large instrument set and multiple endogenous explanatory variables Bowden and Turkington (1984, Chapter 2) recommend reporting canonical correlation of endogenous regressors and instruments. We dutifully report that the geometric mean of the canonical correlations between the regressors and the instrument set for our most preferred specification, column (3) of Table 1, is 0.387 so that we should not have the problems associated with weak instruments in our model of choice.[16]

Summary and Implications of Step One. Step one estimates of intratemporal preferences establish that the contemporaneous gross hourly wage is not exogenous to the estimated labor supply function, which agrees with the static results from Flood and MaCurdy (1992) and conflicts with the econometric assumptions required for maximum-likelihood estimation of labor supply tax effects. We also found that

---

[16]As another point of reference to use in supporting our GMM results we note that the biased and inefficiently estimated OLS coefficients (standard errors) for our preferred specification, column (3) of Table 1, are $\alpha = -37.7224$ (3.3779), $\delta = 0.0185$ (0.1192), and $\phi = -0.3819$ (0.1138).

intertemporally nonseparable models with current and lagged assets dominate time-separable life-cycle consistent labor supply models. Using our most preferred results in step one, column (3) of Table 1, the mean estimated uncompensated wage elasticity is about 0.13 and the mean estimated compensated wage elasticity is 0.14 to 0.15. The estimated tax elasticity of labor supply is –0.06, so that hours worked by prime-aged men would fall slightly more than one-half percent in the short run with a 10 percent increase in U.S. marginal tax rates.

5.2 Step Two: Estimating Intertemporal Preferences

The previous section showed that the most appropriate estimated parameters from step one to use in step two come from GMM fixed-effects labor supply estimates with reported wages and conditioning on current and lagged assets. Treating the estimated labor supply parameters as known when estimating the empirical Euler equation for the marginal utility of net wealth (6) we can then identify intertemporal preferences, including the subjective discount rate, ρ, and the coefficients of relative risk aversion, σ_k, which are components of the long-run (life-cycle) labor supply elasticities. The embedded risk-aversion equation has a constant term plus (changes in) wealth, in the number of children living at home, and in health status.

We used a basic instrument set with 20 instruments in the GMM estimator in step two: a constant; gross and net reported wages, the net 3-month T-bill rate; children, age, age^2, the interaction of age and education, health status, and home ownership in years $t-3$ and $t-4$; plus net wealth in year $t-4$. Euler equation estimates from step two appear in Table 3. As in step one we examine the importance of adding time dummies to the instrument set in columns (2) and (4).[17] [Insert Table 3 here.]

We estimated four specifications of the intertemporal Euler equation, a common discount rate versus person-specific discount rate with and without time dummies in the

---

[17]The geometric mean canonical correlation between the endogenous regressors and the instrument set with time dummies in step two is 0.175.

instrument set. In the interest of space and because the subjective discount rate seems unlikely to be constant across workers but rather likely to capture heterogeneity of intertemporal preferences we will only discuss the person-specific discount rate specifications of Table 3. The overidentifying restrictions are satisfied and the heterogeneous discount rate specification in columns (3) and (4) dominate the common discount rate specification in columns (1) and (2).[18] Because the heterogeneous life-cycle consistent labor supply specification dominated a homogeneous life-cycle consistent labor supply specification it is not surprising that a specification check in step two also locates discount rate heterogeneity.

The mean value of the estimated person-specific discount rates is 0.034, which is at the upper end of the range of estimates in the consumption literature (Hansen and Singleton 1982, Deaton 1992). The estimated constant coefficient of relative risk preferences, $\hat{\sigma}_0$, is positive but less than unity, indicating risk aversion in the preferred specifications of columns (3) and (4) of Table 3. Risk aversion increases with wealth and poor health as the estimated values of σ_A and σ_H are both positive.

Uncertainty and the Rational-Expectations Hypothesis. The econometric labor supply model we use has the rational-expectations of uncertain economic outcomes, which implies that past forecast errors do not influence current decisions or cause revisions in the marginal utility of net wealth. If our underlying model correctly specifies the evolution of life-cycle labor supply only contemporaneous innovations to components of wealth should cause revisions in the marginal utility of net wealth.

Because the residual from the Euler equation (6) is the innovation to the marginal utility of net wealth $\ln \hat{\varepsilon}_{t+1}$ can function as the dependent variable in a test of the underlying rational expectations hypothesis and in estimating labor supply elasticities with respect to unexpected transitory wage changes. Specifically, let

[18] Using the *LR* test ($df = N-1 = 531$) the implied *p*-values under the null hypothesis of a common discount rate for the basic and expanded instrument set with time dummies are both 0.000.

$$\ln \hat{\varepsilon}_{t+1} = \zeta_{\varepsilon\omega}(\omega_{t+1} - E_t\omega_{t+1}) + \zeta_{\varepsilon r}(r_{n,t+1} - E_t r_{n,t+1}) + \zeta_{\varepsilon A}(A_{t+1} - E_t A_{t+1}), \quad \textbf{(21)}$$

where E_t indicates expectation at time t. Under rational expectations lagged innovations should have no additional predictive power when estimating equation (21), $\hat{\zeta}_{\varepsilon\omega}$ and $\hat{\zeta}_{\varepsilon A}$ should be negative, and $\hat{\zeta}_{\varepsilon r}$ can take either sign or zero (Altonji and Ham 1990). Because intertemporally nonseparable budgets make the lagged error at $t-1$ endogenous, the appropriate comparison is between the fit of the models including (omitting) $\ln \hat{\varepsilon}_{t-2}$ in the instrument set.

Following the lead of Altonji and Ham (1990) we estimated a semi-logarithmic Euler equation for the marginal utility of net wealth (21) in two steps.[19] Using instruments dated $t-j(j \geq 2)$ we first produced time t expectations of period $t+1$'s net wage, net interest rate, and net wealth. Using instruments dated $t-k(k \geq 1)$ we then estimated the arguments on the right-hand side of (21), which are the innovations in period t's expected net wage, net interest rate, and net wealth.

In both steps involved in estimating the ancillary equation (21) there were 20 instruments including a constant plus the values at $t-1$, $t-2$, and $t-3$ of net assets, children at home, health status, the net three-month T-bill rate, and age and values at $t-2$ and $t-3$ of gross and net wages. For completeness we again examined the econometric consequences of allowing economy-wide shocks by including time dummies in the instrument set in half the estimated Euler equations.

Because the over-identifying restrictions on the ancillary regressions presented in Table 4 are not as readily accepted as in the cases of labor supply and the indirect utility function, a limited-information approach seems best. Practically speaking, both specifications where the innovations at $t-2$ are excluded from the instrument set, rows (1) and (3), give comparable economic results. All three regressors have the expected a priori signs, and the interest rate and wealth innovations' coefficients are statistically

---

[19]The two steps are necessary because the standard econometric approach to rational expectations results in a matrix of explanatory variables that is singular here.

significant at the one percent level while the wage innovation coefficient is significant at the five percent level in row (3). Unexpected increases in wages or wealth diminish marginal utility while unexpected increases in the interest rate raise the marginal utility of net wealth. The dominance of the specifications in rows (1) and (3) of Table 4 based on their *p*-values also means that we reject the lagged forecast error at time *t–2* as a valid instrument and do not to reject the null hypothesis of rational expectations. [Insert Table 4 here.]

5.3 Labor Supply Elasticities

Because of its relevance to economic policy a focal point of the empirical literature on life-cycle labor supply has been the λ-constant elasticity, which is the labor supply response to an expected wage change. The λ-constant labor supply elasticity can be computed from the intertemporal substitution elasticity (ISE), which is the labor supply response to an expected change in all prices (Browning 1985). The λ-constant elasticity, also known as Frisch's specific-substitution elasticity, is $e_{\lambda} = [e_{u} + \Psi(e_{A})^{2}(wh / A)]$, where e_u is the compensated wage elasticity, Ψ is the ISE, e_A is the wealth elasticity, and (*wh/A*) is current earnings relative to wealth. The sample mean λ-constant elasticity in Table 3 is about 0.15 in both the common and worker-specific discount rate specifications. As required by the assumption of strictly concave preferences the λ-constant elasticity in Table 3 is larger than the compensated wage elasticity in column (3) of Table 1, which is larger than the uncompensated wage elasticity in column (3) of Table 1.

To understand how estimated labor supply elasticities vary importantly across families Table 5 presents six elasticities of interest by wealth quartile. Notice that the (un)compensated and λ-constant elasticities rise with wealth so that the hours response to wage changes are about 50 percent larger for the wealthiest 25 percent compared to the poorest 25 percent of prime-aged men. Examining only elasticity averages in Table 1 would also obscure the distributional consequences of tax policy. As wealth increases so does workers' responsiveness to taxation so that the marginal tax rate elasticity doubles as one moves from the lowest to the highest wealth quartiles in Table 5.[20] We return to the issue of wealth and its interaction with tax reforms in the next section. [Insert Table 5 here.]

The last elasticity we mention in Table 5 has some interest for macro labor economists. The mean difference between realized and expected wages is about 0.233. Using the wage coefficient from row (3) of Table 4 the wealth effect of an unanticipated wage change is then $(-0.13 \times 0.233) \cong -0.03$, and the average labor supply elasticity of an unanticipated wage change is approximately $(0.15 - 0.03) = 0.12$. The uncertainty component or macro element of the total labor supply response to an unanticipated cyclic wage change is nontrivial in the highest wealth quartile, however. The wealth effect that accompanies an unexpected wage change shrinks the labor supply response of the wealthiest quartile of workers by about eight percent compared to an expected wage change. The increasing wealth effect across wealth quartiles standardizes the total elasticity of labor supplied with respect to an unexpected wage change at about 0.10 for all wealth quartiles.

6. Implications for Tax Policy

In applying the economic literature on the welfare costs of (non)linear income and commodity taxes we use the estimated intra and interperiod preferences discussed in Section 5 to form the indirect utility function and the associated expenditure function, $\tilde{E}[\omega_t, V_t(\omega_t, A_{t-1}, A_t)]$, which we then use in so-called exact measures of changes in economic well being. We examine two measures of welfare change in the United States due to recent changes in the income tax laws.

---

[20]A clarifying point. By construction our elasticity calculations are a positive function of (ω/h), which on average is 40 percent higher in the highest wealth quartile than in the lowest wealth quartile. However, the partial derivative of labor supplied with respect to the marginal tax rate is not the same across workers and the marginal tax rate elasticity of labor supplied differs by 100 percent between the lowest and highest wealth quartiles.

6.1 Deadweight Loss Measures

One measure of welfare change we calculated with our estimated preferences parameters is a hypothetical payment to the government by the typical prime-aged married male worker under the pre tax-reform (wage and capital) income that would leave welfare unchanged under the post tax-reform income (Kay 1980). The hypothetical payment, or equivalent variation measure, compares an initial distorted equilibrium with a final distorted equilibrium and is of the form

$$D(EV) = \widetilde{\mathrm{E}}[\omega_2, V_2(\omega_2, A_1, A_2 - T_2)] - \widetilde{\mathrm{E}}[\omega_1, V_2(\omega_2, A_1, A_2 - T_2)]$$
$$-T_2(W_2 h_2, r_2 A_1, D_2, Ex_2) + T_1(W_1 h_1, r_1 A_0, D_1, Ex_1), \qquad \textbf{(22)}$$

where ω_1 and ω_2 are the pre and post reform net marginal wage rates; A_1 and A_2 are pre and post-reform assets; and T_t $(t = 1,2)$ is the value of actual tax payments at pre and post-reform levels, which depend on gross labor earnings ($W_t h_t$), interest income ($r_t A_{t-1}$), deductions (D_t), and exemptions (Ex_t). The deadweight loss measure in (22) is a consistent ordinal indicator of welfare in that a beneficial tax reform leaving tax payments constant reduces *D(EV)* (Auerbach 1985).

The equivalent variation measure in (22) fixes utility at its post-reform level, which under joint nonlinear income taxation is a function of post-reform wage and pre and post-reform assets, and lets wage differences imply a change in worker well being across tax regimes. An alternative calculation uses the change in consumers' surplus, called welfare variation, where the wage vector is held at a reference level, such as the pre tax-reform level, and utility differs when taxes change (King 1983, Triest 1987). The welfare variation measure of moving from one distorted equilibrium to another is

$$D(WV) = \widetilde{\mathrm{E}}[W, V_1(\omega_1, A_0, A_1 - T_1)] - \widetilde{\mathrm{E}}[W, V_2(\omega_2, A_1, A_2 - T_2)]$$
$$-T_2(W_2 h_2, r_2 A_1, D_2, Ex_2) + T_1(W_1 h_1, r_1 A_0, D_1, Ex_1), \qquad \textbf{(23)}$$

where the reference point is the gross wage, W. Joint nonlinear taxation ties the periods together by making V_2 depend on pre and post-reform wealth. The deadweight loss measure in (23) is the change in consumer utility less the actual revenue extracted. As long as the reference price vector is fixed across alternatives the welfare variation measure is a consistent ordinal measure of utility such that any revenue neutral tax change that raises utility, $V_1 < V_2$, will reduce $D(WV)$.

Although the ordinal rankings of the equivalent variation and welfare variation measures may differ unless the initial tax vector is applied to goods with zero income elasticities, both measures will give similar ordinal rankings under revenue neutral tax changes (Triest 1987).

6.2 Tax Simulation Details

In addition to simulating changes in economic well being we also simulated the labor supply responses to four federal income tax reforms. Because the system we estimated in Section 5 is a nonlinear function of the income tax schedule the marginal tax rate is endogenously determined with hours worked.[21] We then applied numerical methods to solve for the endogenous variables.

The nonlinear simultaneous equations system we solved describes labor supplied, wealth accumulation, the marginal tax rate, and tax payments as

$$h_{it} = 27.8312 W_{it}(1-\tau_{it}) - 0.4941 A_{it-1} - 2.0278 A_{it} + X_{it}\hat{\gamma} + \hat{\eta}_i + \xi_{it}, \quad (24)$$

$$A_{it} = (1 + r_t(1-\tau_{it}))A_{it-1} + W_{it}(1-\tau_{it})h_{it} - C_{it} - T(I_{it}), \quad (25)$$

$$\tau_{it} = [\Phi_{1it} - \Phi_{2it}]b(I_{it}) + \Phi_{2it}\tau_{uit}, \text{ and} \quad (26)$$

$$T(I_{it}) = \int \tau(I_{it}) dI_{it}, \quad (27)$$

where C_{it} is consumption, $\hat{\eta}_i$, is the estimated person-specific fixed effect, and τ_{it} is the nonlinear marginal tax rate that depends on hours worked and assets.

[21]To be consistent with past research our structural simulation model takes the spouses' labor supply decisions as sequential wherein the husband first chooses his labor supply subject to a marginal tax rate calculated at wife's earnings of zero. In the sequential decision making underlying our labor supply simulations the wife's labor and interest incomes do not contribute to the husband's marginal tax rate calculations used in planning. We have, however, experimented by adding the wife's labor earnings to virtual saving in the models in Table 2 with no change in our conclusions using either the smooth marginal tax rates or the marginal tax rates reported in the PSID.

We solved the system in (24)–(27) via backward induction using the Gauss-Newton algorithm and 100 Monte Carlo draws for each of the 532 men from the distribution $\xi \sim N(0, \sigma_{\varepsilon} = 458)$ where 458 is the estimated standard deviation of the error in the first-differences model in Table 1, column (3).[22] We then used simulated values in deadweight loss calculations of four tax regime changes.

6.3 Four Tax Regime Changes

We calculated measures of the comparative welfare effects of four U.S. federal tax regimes. In particular, we examined (1) the 1987 (post-TRA86) U.S. income tax structure versus a regime where taxes are absent, (2) the 1987 U.S. income tax structure versus a 10 percent across-the-board rate cut, (3) the 1987 income tax rates versus the 1981 (pre-ERTA) income tax regime, and (4) the 1987 income tax rates and tax base versus the pre-ERTA income tax regime.

Because our tax experiments refer to tax cuts our deadweight loss calculations are the maximum amounts the typical prime-aged married male worker would pay to lower his taxes. In all four cases the equivalent-variation (22) and welfare change (23) measures are close, differing no more than one percent, and giving consistent ordinal rankings of welfare changes. The particular tax reform and the worker's location in the wealth distribution determines labor supply with the greatest labor supply response coming from the wealthiest workers.

Eliminating Income Taxes. Estimates presented in Table 6 show that eliminating income taxes would lead prime-aged married men to work about four percent more hours on average, which is an estimate that is 60 percent larger than Triest (1990) who used a static labor supply model. Workers in the upper quartile of the wealth distribution would supply about seven percent more hours. The typical U.S. prime-aged married male worker would pay up to about 23 percent of his adjusted gross income to eliminate the

---

[22]Tripling the number of Monte Carlo draws changed the simulated values by no more than one percent.

current progressive income taxation.[23] By additional comparison Hausman's (1981b) widely cited estimated labor supply effects of removing income taxes are higher (about eight percent) and estimated willingness to pay much lower (two percent) than our estimates. To explain, Hausman's labor supply income tax effects are driven by a large income effect whereas our deadweight loss calculations reflect a larger lifetime substitution effect. By adding capital income taxation to a life-cycle model including worker heterogeneity and time nonseparable utility we have located a greater extent of the excess burden of income taxes than Hausman located using a time-separable static model estimated with a single cross-section of the Panel Study of Income Dynamics. [Insert Table 6 here.]

An Across-the-Board Rate Cut. A 10 percent across-the-board rate cut from the current tax structure would cause about a 0.6 percent increase in the labor supplied annually by prime-aged married men (about 13 hours) accompanied by a reduction in government tax revenues of about six percent. Our typical married male worker would pay one to two percent of adjusted gross income to have a 10 percent cut while the wealthiest 25 percent would pay two to three percent of AGI for a 10 percent reduction in income tax rates.

TRA86 Rate Cuts. Results from our third calculation, comparing the labor supply response and deadweight loss from moving from the pre-ERTA (1981) income tax regime to the post-TRA86 (1987) income tax rates reveals that the average prime-aged married man raised hours supplied by two percent and would have paid 11 percent of his adjusted gross income for the change to TRA86 tax rates. Our estimates are that the wealthiest workers increased their labor supplied by about four percent and had about a

---

[23]We used the traditional Kay and King measures of deadweight loss here because the welfare effects of eliminating the current federal income tax compare a distorted initial equilibrium to an undistorted final equilibrium.

14 percent improvement in their economic well being due to taxes under TRA86 compared to the pre-ERTA tax regime.

TRA86 Rate and Base Cuts. In our fourth simulation in Table 6 we compare the labor supply and deadweight loss response from moving from the pre-ERTA (1981) income tax regime to the post-TRA86 (1987) income tax rates and tax base. TRA86 took over six million people off the tax rolls so that incorporating both tax rate and base changes should make the simulated hours response higher than when incorporating only the tax rate changes under TRA86. Table 6 shows a 2–5 percent increase in labor supplied across the four quartiles in case (4), our simulation of the dual effects of the rate and base changes under TRA86.[24] Comparing cases (3) and (4) implies the tax base effect of TRA86. Table 6 implies that changes in the tax base under TRA86 increased both average labor supplied and the welfare improvement under TRA86 by about an additional 50 percent with the largest effects occurring as expected in the lowest two wealth quartiles.

7. Conclusion

Our research has developed a structural model of life-cycle labor supply of workers facing a nonlinear tax structure over both wage and interest incomes, which generates an intertemporally nonseparable budget constraint and labor supply function. We included intertemporal nonseparability econometrically by estimating a life-cycle consistent labor supply equation that is conditioned on start-of-period and end-of-period assets. With data for prime-aged men for 1978–1987 from the Panel Study of Income Dynamics and a smoothed nonlinear intertemporal net budget constraint in a two-step generalized method-of-moments estimator we first identified intraperiod then interperiod-preferences parameters.

---

[24]As a benchmark to use in judging labor supply simulations actual average hours worked increased by three to four percent during 1981–1987 for prime-aged men.

Our GMM estimator admitted comparisons of permanent versus transitory and expected versus unexpected wage changes so that we could develop labor supply elasticities of interest to both micro and macro economists. Estimates rejected labor supply models with intertemporally separable budget constraints in favor of intertemporally nonseparable labor supply. We used our labor supply estimates in stochastic simulations of the welfare gains from recent tax reforms that produced a flatter income tax system in the United States. Our results emphasize that the study of the work-incentive effects of income taxation should use longitudinal data, which permit incorporating the empirical realism of latent worker heterogeneity and time nonseparable decisions due to joint nonlinear taxation of wage and nonwage incomes.

References

Ahn, Seung Chan, Young Hoon Lee, and Peter Schmidt (1994). "GMM Estimation of a Panel Data Regression Model with Time-Varying Individual Effects," Working Paper, Michigan State University, Department of Economics.

Altonji, Joseph G. (1986). "Intertemporal Substitution in Labor Supply: Evidence from Micro Data," *Journal of Political Economy* 94:3, S176–S215.

Altonji, Joseph G. and John Ham (1990). "Intertemporal Substitution, Exogeneity, and Surprises: Estimating Life Cycle Models for Canada," *Canadian Journal of Economics* 23:1, 1–43.

Altonji, Joseph G. and Lewis M. Segal (1994). "Small Sample Bias in GMM Estimation of Covariance Structures," Technical Working Paper Number 156, National Bureau of Economic Research, Inc.

Amemiya, Yasuo (1985). "Instrumental Variables Estimator for the Nonlinear Errors-in-Variables Model," *Journal of Econometrics* 28:3, 273–289.

Amemiya, Yasuo (1990). "Two-stage Instrumental Variables Estimators for the Nonlinear Errors-in-Variables Model," *Journal of Econometrics* 44:3, 311–332.

Auerbach, Alan J, (1985). "The Theory of Excess Burden and Optimal Taxation," in A.J. Auerbach and M. Feldstein (eds.), *Handbook of Public Economics*, Volume 1, Amsterdam, North-Holland, 61–127.

Blomquist, N. Soren (1985). "Labor Supply in a Two-Period Model: The Effect of a Nonlinear Progressive Income Tax," *Review of Economic Studies* 52:3, 515–524.

Blundell, Richard and Ian Walker (1986). "A Life-Cycle Consistent Empirical Model of Family Labour Supply Using Cross-Section Data," *Review of Economic Studies* 53:4, 539–588.

Blundell, Richard, Vanessa Fry, and Costas Meghir (1990). "Preference Restrictions in Microeconometric Models of Life-Cycle Behavior Under Uncertainty," in *Microeconometrics: Surveys and Applications*, J.P. Florens, M. Ivaldi, J.J. Laffont, and F. Laisney (eds.), Oxford: Basil Blackwell, 41–54.

Blundell, Richard, Costas Meghir, and Pedro Neves (1993). "Labour Supply and Intertemporal Substitution," *Journal of Econometrics* 59:112, 137–160.

Bound, John, David A. Jaeger, and Regina M. Baker (1995). "Problems With Instrumental Variables Estimation When the Correlation between the Instruments and the Endogenous Explanatory Variable is Weak," *Journal of the American Statistical Association* 90:430, 443–450.

Borjas, George J. (1980). "The Relationship Between Wages and Weekly Hours of Work: The Role of Division Bias," *Journal of Human Resources* 15:3, 409–423.

Bosworth, Barry and Gary Burtless (1992). "Effects of Tax Reform on Labor Supply, Investment, and Saving," *Journal of Economic Perspectives* 6:1, 3–26.

Bover, Olympia (1991). "Relaxing Intertemporal Separability: A Rational Habits Model of Labor Supply Estimated from Panel Data," *Journal of Labor Economics* 9:1, 85–100.

Bowden, Roger J. and Darrell A. Turkington (1984). *Instrumental Variables*, Cambridge: Cambridge University Press.

Browning, Martin (1985). "Which Demand Elasticities Do We Know and Which Do We Need to Know for Policy Analysis?" Working Paper, Department of Economics, McMaster University, April.

Browning, Martin (1986). "The Costs of Using Frisch Demand Functions That Are Additive in the Marginal Utility of Expenditure," *Economics Letters* 21:3, 205–207.

Burtless, Gary and Jerry Hausman (1978). "The Effect of Taxation on Labor Supply: Evaluating the Gary Negative Income Tax Experiment," *Journal of Political Economy* 86:6, 1103–1130.

Chamberlain, Gary (1984). "Panel Data," *Handbook of Econometrics*, Z. Griliches and M.D. Intriligator (eds.), Amsterdam: North Holland, 1247–1320.

Conway, Karen Smith and Thomas J. Kniesner (1992). "How Fragile are Male Labor Supply Function Estimates?" *Empirical Economics* 17:1, 169–182.

Conway, Karen Smith and Thomas J. Kniesner (1994). "Estimating Labor Supply with Panel Data and Taxes," *Economics Letters* 44:1, 27–33.

Deaton, Angus (1992). *Understanding Consumption*, Oxford: Oxford University Press.

Eissa, Nada (1995). "Taxation and Labor Supply of Married Women: The Tax Reform Act of 1986 As A Natural Experiment," Working Paper Number 5023, National Bureau of Economic Research, Inc., February.

Engen, Eric M., William G. Gale, and John Karl Scholz (1994). "Do Saving Incentives Work?," *Brookings Papers on Economic Activity* 1, pp. 85–151.

Flood, Lennert and Thomas MaCurdy (1992). "Work Disincentive Effects of Taxes: An Empirical Analysis of Swedish Men," *Carnegie-Rochester Series on Public Policy*, C. Plosser and A. Meltzer (eds.) 37, Amsterdam: North Holland, 239–278.

Griliches, Zvi and Jerry Hausman (1986). "Errors in Variables in Panel Data," *Journal of Econometrics* 31:1, 93–118.

Hall, Alastair (1993). "Some Aspects of Generalized Method of Moments Estimation," *Handbook of Statistics, Volume 11*, G.S. Maddala, C.R. Rao, and H.D. Vinod (eds.), Amsterdam: Elsevier Science Publishers B.V., 393–418.

Hall, Robert E. and Alvin Rabushka (1983). *Low Tax, Simple Tax, Flat Tax*, New York: McGraw-Hill.

Hansen, Lars P. and Kenneth J. Singleton (1982). "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models," *Econometrica* 50:5, 1269–1286.

Hausman, Jerry (1981a). "Labor Supply," in *How Taxes Affect Economic Behavior*, H. Aaron and J. Pechman (eds.), Washington, DC: Brookings Institution, 27–83.

Hausman, Jerry (1981b). "Income and Payroll Tax Policy and Labor Supply," in *The Supply-Side Effects of Economic Policy*, L. H. Meyer (ed.), Boston: Kluwer Academic Publishers, 173–202.

Heckman, James and Thomas MaCurdy (1980). "A Life-Cycle Model of Female Labour Supply," *Review of Economic Studies* 47:1, 47–74.

Heckman, James and Thomas MaCurdy (1982). "Corrigendum on a Life-Cycle Model of Female Labour Supply," *Review of Economic Studies* 49, 659–660.

Hotz, V. Joseph, Finn E. Kydland, and Guilerme L. Sedlacek (1988). "Intertemporal Preferences and Labor Supply," *Econometrica* 56:2, 335–360.

Hsiao, Cheng (1989). "Consistent Estimation for some Nonlinear Errors-in-Variables Models," *Journal of Econometrics* 41:1, 159–185.

Hubbard, R. Glenn, Jonathan Skinner, and Stephen P. Zeldes (1994). "Expanding the Life-Cycle Model: Precautionary Saving and Public Policy," *American Economic Review, Papers and Proceedings* 84:2, 174–179.

Hubbard, R. Glenn, Jonathan Skinner, and Stephen P. Zeldes (1995). "Precautionary Saving and Social Insurance," *Journal of Political Economy*, 103:2, 360–399.

Jakubson, George J. (1988). "The Sensitivity of Labor Supply Parameter Estimates to Unobserved Individual Effects: Fixed and Random Effects Estimates in a Nonlinear Model Using Panel Data," *Journal of Labor Economics* 6:3, 302–329.

Kay, J. A. (1980). "The Deadweight Loss of a Tax System," *Journal of Public Economics* 13:1, 111–119.

Keane, Michael P. and David E. Runkle (1992). "On the Estimation of Panel-Data Models With Serial Correlation When Instruments Are Not Strictly Exogenous," *Journal of Business and Economic Statistics* 10:1, 1–9.

Killingsworth, Mark (1983). *Labor Supply*, Cambridge UK: Cambridge University Press.

Kimmel, Jean and Thomas J. Kniesner (1993). "The Intertemporal Substitution Hypothesis is Alive and Well (But Hiding in the Data)," Working Paper Number 93-014, Indiana University, Bloomington, Department of Economics.

King, Mervyn (1983). "Welfare Analysis of Tax Reforms Using Household Data," *Journal of Public Economics* 21:2, 183–214.

Kniesner, Thomas J. and Arthur H. Goldsmith (1987). "A Survey of Alternative Models of the Aggregate US Labor Market," *Journal of Economic Literature* 25:3, 1241–1280.

MaCurdy, Thomas (1981). "An Empirical Model of Labor Supply in a Life-Cycle Setting," *Journal of Political Economy* 89:6, 1059–1085.

MaCurdy, Thomas E. (1983). "A Simple Scheme for Estimating An Intertemporal Model of Labor Supply and Consumption in the Presence of Taxes and Uncertainty," *International Economic Review* 24:2, 265–289.

MaCurdy, Thomas E. (1985). "Interpreting Empirical Models of Labor Supply in an Intertemporal Framework with Uncertainty," *Longitudinal Analysis of Labor Market Data*, J. Heckman and B. Singer (eds.), Cambridge, UK: Cambridge University Press, 111–155.

MaCurdy, Thomas (1992). "Work Disincentive Effects of Taxes: A Reexamination of Some Evidence," *American Economic Review* 82:2, 243–249.

MaCurdy, Thomas E., David Green, and Harry Paarsch (1990). "Assessing Empirical Approaches for Analyzing Taxes and Labor Supply," *Journal of Human Resources* 25:3, 415–490.

Maeshiro, Asatoshi and Shapoor Vali (1988). "Pitfalls in the Estimation of a Differenced Model," *Journal of Business and Economic Statistics* 6:4, 511–515.

Mankiw, N. Gregory, Julio Rotemberg, and Lawrence Summers (1985). "Intertemporal Substitution in Macroeconomics," *Quarterly Journal of Economics* 100:1, 225–252.

Moffitt, Robert (1992). "Incentive Effects of the U.S. Welfare System," *Journal of Economic Literature* 30:1, 1–61.

Newey, Whitney K. (1984). "A Method of Moments Interpretation of Sequential Estimators," *Economics Letters* 14:2, 201–206.

Newey, Whitney K. (1985). "Generalized Method of Moments Specification Testing," *Journal of Econometrics* 29:3, 229–256.

Newey, Whitney K. (1993). "Efficient Estimation of Models with Conditional Moment Restrictions," *Handbook of Statistics, Volume 11*, G.S. Maddala, C.R. Rao, and H.D. Vinod (eds.), Amsterdam: Elsevier Science Publishers B.V., 419–454.

Newey, Whitney K. and Daniel McFadden (1994). "Large Sample Estimation and Hypothesis Testing," *Handbook of Econometrics, Volume IV*, R. Engle and D. McFadden (eds.), Amsterdam: Elsevier Science Publishers B.V., 2113–2147.

Newey, Whitney K. and Kenneth D. West (1987a). "Hypothesis Testing with Efficient Method of Moments Estimation," *International Economic Review* 28:3, 777–787.

Newey, Whitney K. and Kenneth D. West (1987b). "A Simple, Positive Semi-Definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica* 55:3, 703–708.

Pencavel, John (1986). "Labor Supply of Men," *Handbook of Labor Economics*, O. Ashenfelter and R. Layard (eds.), Amsterdam: North Holland, 3–102.

Rodgers, Willard L., Charles Brown, and Greg J. Duncan (1993). "Errors in Survey Reports of Earnings, Hours Worked, and Hourly Wages," *Journal of the American Statistical Association*, 88:424, 1208–1218.

Rogerson, Richard and Peter Rupert (1991). "New Estimates of Intertemporal Substitution," *Journal of Monetary Economics* 27:2, 255–269.

Runkle, David E. (1991). "Liquidity Constraints and the Permanent-Income Hypothesis," *Journal of Monetary Economics* 27:1, 973–988.

Statistics of Income. "Individual Income Tax Returns," selected years, Washington, DC: Internal Revenue Service.

Stern, Nicholas (1986). "On the Specification of Labour Supply Functions," *Unemployment, Search, and Labour Supply*, R. Blundell and I. Walker (eds.), Cambridge: Cambridge University Press, 143–189.

Triest, Robert K. (1987). "The Effect of Income Taxation on Labor Supply," Ph. D. dissertation, University of Wisconsin.

Triest, Robert K. (1990). "The Effect of Income Taxation on Labor Supply in the United States," *Journal of Human Resources* 25:3, 491–516.

Zeldes, Stephen (1989). "Consumption and Liquidity Constraints: An Empirical Investigation," *Journal of Political Economy* 97:2, 305–346.

Ziliak, James P. (1993). "Three Essays on the Effect of Taxes and Tax Reform on Life-Cycle Labor Supply," Ph. D. dissertation, Indiana University, Bloomington.

Ziliak, James P. (1994). "Does the Choice of Consumption Matter? An Application to the Permanent-Income Hypothesis," Working Paper 163, University of Oregon, Department of Economics.

Appendix: Summary Statistics for Continuously Working Men Aged 22-51 in 1978 for the Years 1978-1987[a]

Variable	Mean	Standard Deviation
Annual Hours of Work	2182.552	492.056
Reported Gross Wage	14.891	7.286
Reported Net Wage	10.224	4.142
Average Gross Hourly Earnings	15.643	8.759
Average Net Hourly Earnings	10.746	5.827
Marginal Tax Rate	0.292	0.069
Liquid Assets[b]	15084.280	50790.111
Home Equity	49196.246	54109.148
Total Wealth	64280.526	81276.849
Virtual Wealth	78879.814	90181.207
Net Saving	3867.784	62743.191
Virtual Saving	5188.941	62893.291
Gross 3-Month T-Bill	0.030	0.018
Net 3-Month T-Bill	0.003	0.017
Age	38.918	8.450
Kids	1.556	1.196
Grades Completed	13.194	2.599
Race (1 = White)	0.919	0.271
Home Owner (1 = Yes)	0.888	0.315

[a] N = 5320. All wealth, price, income variables are in real terms with respect to the 1987 personal consumption expenditure deflator.

[b] Liquid assets equal nominal interest, dividend, and rental income earnings with the first $200 deflated by the average annual passbook saving rate and the remainder deflated by the average annual 3-month T-Bill rate.

Figure 1: Statutory and Differential Marginal Tax Functions in 1978

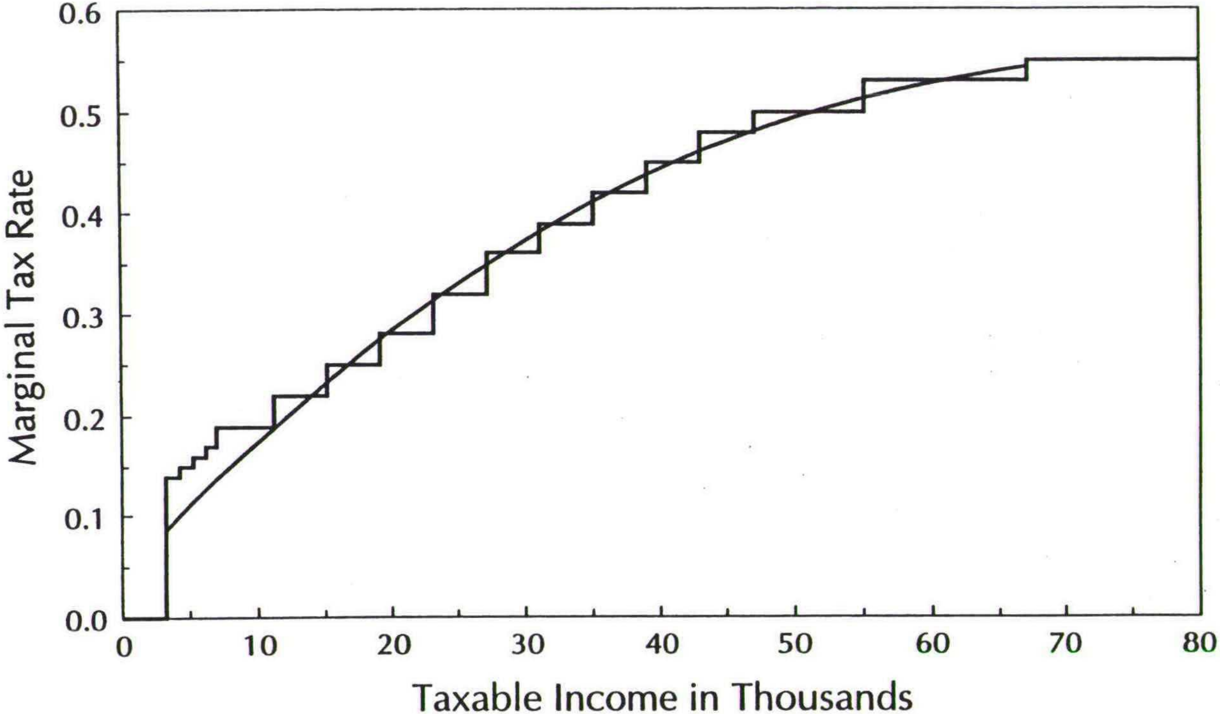

Table 1 Life-Cycle Consistent Labor Supply Equation: Time Nonseparable Model with A_{t-1}, A_t[a]

Variable	Reported Hourly Wage			Average Hourly Earnings		
	(1)	(2)	(3)	(4)	(5)	(6)
ω_t (α)	24.6556 (20.6555)	-24.9649 (6.1268)***	27.8312 (14.9042)*	-16.5966 (10.1754)	-9.5934 (8.5701)	-8.7289 (9.3765)
A_{t-1} (δ) ($1000's)	-0.3698 (0.1905)*	-0.3818 (0.1796)**	-0.4941 (0.2267)**	-0.3983 (0.1727)**	-0.3212 (0.2194)	-0.5534 (0.2032)***
A_t (ϕ) ($1000's)	-1.6211 (0.8141)**	-0.0283 (0.5498)	-2.0278 (0.7852)***	-0.5478 (0.6785)	-0.5207 (1.0365)	-1.2578 (0.6453)**
Uncomp. Wage Elasticity[b]	0.1153 (0.0966)	-0.1167 (0.0286)***	0.1301 (0.0697)*	-0.0832 (0.0510)	-0.0481 (0.0429)	-0.0408 (0.0438)
Lagged Wealth Elasticity	-0.0100 (0.0052)*	-0.0103 (0.0049)**	-0.0135 (0.0062)**	-0.0108 (0.0047)**	-0.0087 (0.0060)	-0.0151 (0.0055)***
Current Wealth Elasticity	-0.0468 (0.0235)**	-0.0008 (0.0159)	-0.0586 (0.0227)***	-0.0158 (0.0196)	-0.0150 (0.0299)	-0.0363 (0.0186)**
Comp. Wage (A_{t-1}) Elasticity	0.1190 (0.0966)	-0.1128 (0.0287)***	0.1351 (0.0697)*	-0.0788 (0.0510)	-0.0446 (0.0430)	-0.0352 (0.0439)
Comp. Wage (A_t) Elasticity	0.1318 (0.0969)	-0.1164 (0.0292)***	0.1508 (0.0701)**	-0.0772 (0.0515)	-0.0424 (0.0444)	-0.0279 (0.0443)
MTR Elasticity[c]	-0.0504 (0.0423)	0.0511 (0.0123)***	-0.0567 (0.0305)*	0.0364 (0.0223)	0.0211 (0.0188)	0.0179 (0.0192)
J-Statistic[d] d.o.f. [p-value]	18.6825 14 [0.1774]	21.1878 15 [0.1309]	23.9234 20 [0.2458]	20.0721 14 [0.1279]	16.5671 15 [0.3454]	27.9624 20 [0.1103]

a Standard errors are in parentheses. Columns (2) and (4) contain the gross wage as an additional instrument while columns (3) and (6) contain time dummies as instruments.

b Elasticities are computed at their mean values: net reported wage = 10.19; net average hourly earnings = 10.93; A_{t-1} = 59.332; A_t = 62.969; h_t = 2179.48; MTR = 0.2979.

c MTR elasticity = $(-\alpha W_t - \phi MTR_t) \times (MTR_t/h_t)$.

d d.o.f. is the number of instruments less parameters estimated and the p-value is for the null hypothesis that the overidentifying restrictions are not rejected.

*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.

Table 2 Life-Cycle Consistent Labor Supply Equation: Time Separable Model with S_t[a]

Variable	Reported Hourly Wage			Average Hourly Earnings		
	(1)	(2)	(3)	(4)	(5)	(6)
ω_t (α)	-24.8865 (12.0730)**	-26.4032 (6.1845)***	-50.3075 (8.1795)***	-33.3578 (7.3385)***	6.4968 (8.3791)	-84.4164 (3.5079)***
S_t (ϕ) ($1000's)	-0.2406 (0.0454)***	-0.2323 (0.0454)***	-0.3394 (0.0230)***	-0.2511 (0.0411)***	-0.0519 (0.0544)	-0.6718 (0.0316)***
Uncomp. Wage Elasticity[b]	-0.1163 (0.0564)**	-0.1234 (0.0289)***	-0.2352 (0.0382)***	-0.1672 (0.0368)***	0.0326 (0.0420)	-0.4232 (0.0176)***
Saving Elasticity	-0.0003 (0.0001)***	-0.0003 (0.0001)***	-0.0005 (3.3E-5)***	-0.0004 (0.0001)***	-0.0001 (0.0001)	-0.0010 (4.9E-5)***
Comp. Wage (S_t) Elasticity	-0.1139 (0.0564)**	-0.1210 (0.0289)***	-0.2317 (0.0382)***	-0.1645 (0.0368)***	0.0331 (0.0420)	-0.4158 (0.0176)***
MTR Elasticity[c]	0.0509 (0.0247)**	0.0541 (0.0127)***	0.1030 (0.0167)***	0.0731 (0.0161)***	-0.0142 (0.0183)	0.1850 (0.0077)***
J-Statistic[d] d.o.f. [p-value]	24.2758 15 [0.0605]	24.4817 16 [0.0795]	39.4987 21 [0.0085]	23.5778 15 [0.0726]	7.7816 16 [0.9551]	67.5975 21 [0.0000]

[a] Standard errors are in parentheses. Columns (2) and (4) contain the gross wage as an additional instrument while columns (3) and (6) contain time dummies as instruments.

[b] Elasticities are computed at their mean values: net reported wage = 10.19; net average hourly earnings = 10.93; S_t = 3.084; h_t = 2179.48; MTR = 0.2979.

[c] MTR elasticity = $(-\alpha W_t - \phi MTR_t) \times (MTR_t/h_t)$.

[d] d.o.f. is the number of instruments less parameters estimated and the p-value is for the null hypothesis that the overidentifying restrictions are not rejected.

*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.

Table 3: Intertemporal Euler Equation[a]

Variable	Common Discount Rate		Person-Specific Discount Rate	
	(1)	(2)	(3)	(4)
Subjective Discount Rate	0.0662 (0.0193)*** {0.0355}*	0.0292 (0.0226) {0.0387}		
Constant (σ_0)	-0.4210 (0.2662) {0.2573}	-0.9110 (0.2694)*** {0.2374}***	0.7978 (0.4475)*	0.4187 (0.3635)
Assets ($\sigma_{A,t}$)	0.0037 (0.0014)*** {0.0062}	0.0074 (0.0015)*** {0.0062}	0.0061 (0.0019)***	0.0023 (0.0013)*
Children ($\sigma_{K,t}$)	0.0291 (0.0379) {0.0222}	0.0372 (0.0471) {0.0643}	-0.3781 (0.2006)*	-0.2648 (0.1669)
Health Status ($\sigma_{H,t}$)	-0.0071 (0.2733) {0.3733}	0.7661 (0.3402)** {0.4958}	0.5846 (0.3098)*	0.5571 (0.2586)**
λ-Constant Elasticity (e_λ)[b]	0.1477	0.1494	0.1513	0.1530
J-Statistic[c] d.o.f [p-value]	26.7807 15 [0.0306]	36.2675 20 [0.0143]	19.8931 16 [0.2251]	36.3300 20 [0.0141]

[a] Standard Errors are in parentheses and corrected standard errors are in { }. The first-step indirect utility parameters come from column (3) of Table 1. Columns (2) and (4) have time dummies appended to the instrument set.

[b] $e_\lambda = e_u + \Psi(e_{At})^2(\omega_t h_t / A_t)$ is computed at its mean value, where Ψ is the intertemporal substitution elasticity with respect to a change in all goods prices.

[c] d.o.f. is the number of instruments less parameters and the p-value reported is for the null that the overidentifying restrictions are not rejected.

*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.

Table 4: Marginal Utility of Net Wealth Updating Equation[a]

	Wage Innovation ($\zeta_{\epsilon\omega}$)	Interest Rate Innovation ($\zeta_{\epsilon r}$)	Wealth Innovation ($\zeta_{\epsilon A}$)	2-Period Lag Error	J-Statistic[b] [d.o.f., p-value]
(1)	-0.1236 (0.0749)	0.0397 (0.0145)***	-0.0080 (0.0024)***		27.7499 [17,0.0479]
(2)	-0.0685 (0.0719)	0.0447 (0.0144)***	-0.0082 (0.0023)***	instrument	33.2849 [18,0.0154]
(3)	-0.1345 (0.0648)**	0.0328 (0.0124)***	-0.0044 (0.0014)***		31.4296 [17,0.0177]
(4)	-0.0744 (0.0566)	0.0335 (0.0117)***	-0.0050 (0.0014)***	instrument	36.8990 [18,0.0054]

[a] Standard errors are in parentheses. The dependent variable for rows (1) and (2) are constructed by the person-specific discount rate model without time dummies, while rows (3) and (4) include time dummies.

[b] d.o.f. is the number of instruments less parameters estimated and the p-value reported is for the null hypothesis that the overidentifying restrictions are not rejected.

*, **, *** denotes significance at the 10, 5, and 1 percent levels.

Table 5: Distribution of Selected Elasticities by Wealth Quartiles[a]

	0-25 Percent	25-50 Percent	50-75 Percent	75-100 Percent
Uncompensated Wage	0.1112	0.1193	0.1328	0.1557
Compensated Wage (e_u)	0.1288	0.1380	0.1538	0.1809
Marginal Tax Rate	-0.0404	-0.0465	-0.0581	-0.0830
λ-Constant (e_λ)[b] (Common)	0.1281	0.1373	0.1529	0.1557
λ-Constant (e_λ)[b] (Person-Specific)	0.1171	0.1435	0.1555	0.1815
Wage Innovation ($e_{\zeta\omega}$)[c]	0.0059	-0.0186	-0.0623	-0.0784

[a] Elasticities are computed at the mean values of variables within each quartile using the parameters from models with time dummies in the instrument set.

[b] $e_\lambda = e_u + \Psi(e_{At})^2(\omega_t h_t / A_t)$.

[c] $e_{\zeta\omega} = \zeta_{\epsilon\omega}(\omega_{t+1} - E_t(\omega_{t+1}))$

Table 6: Hours and Welfare Response to Alternative Tax Reforms by Wealth Quartile

		Change in Hours	Change in Tax Payments	Equivalent Variation (%AGI)	Welfare Variation (%AGI)
(1) No-Tax Case	Average	4.01%	-100.00%	-22.56%	-22.74%
	1st Quartile	2.49	-100.00	-17.21	-17.30
	2nd Quartile	2.82	-100.00	-17.48	-17.56
	3rd Quartile	3.94	-100.00	-20.54	-20.67
	4th Quartile	6.94	-100.00	-30.27	-30.65
(2) 10 Percent Tax Cut	Average	0.61	-6.28	-1.74	-1.75
	1st Quartile	0.02	-9.25	-1.37	-1.38
	2nd Quartile	0.68	-8.73	-1.38	-1.39
	3rd Quartile	0.62	-7.41	-1.57	-1.57
	4th Quartile	1.13	-4.53	-2.29	-2.31
(3) Pre-ERTA to Post-TRA86 Tax Rate Cut	Average	2.05	-37.56	-11.04	-11.16
	1st Quartile	1.71	-40.57	-8.65	-8.71
	2nd Quartile	1.01	-39.69	-9.06	-9.12
	3rd Quartile	2.04	-39.32	-10.39	-10.47
	4th Quartile	3.54	-35.49	-14.14	-14.37
(4) Pre-ERTA to Post-TRA86 Tax Rate and Base Cut	Average	3.12	-46.17	-15.66	-15.82
	1st Quartile	2.39	-49.53	-13.80	-13.90
	2nd Quartile	2.30	-45.87	-13.81	-13.90
	3rd Quartile	2.93	-44.43	-15.29	-15.43
	4th Quartile	4.98	-45.96	-18.18	-18.46

No.	Author(s)	Title
94115	H. Uhlig and N. Yanagawa	Increasing the Capital Income Tax Leads to Faster Growth
9501	B. van Aarle, A.L. Bovenberg and M. Raith	Monetary and Fiscal Policy Interaction and Government Debt Stabilization
9502	B. van Aarle and N. Budina	Currency Substitution in Eastern Europe
9503	Z. Yang	A Constructive Proof of a Unimodular Transformation Theorem for Simplices
9504	J.P.C. Kleijnen	Sensitivity Analysis and Optimization of System Dynamics Models: Regression Analysis and Statistical Design of Experiments
9505	S. Eijffinger and E. Schaling	The Ultimate Determinants of Central Bank Independence
9506	J. Ashayeri, A. Teelen and W. Selen	A Production and Maintenance Planning Model for the Process Industry
9507	J. Ashayeri, A. Teelen and W. Selen	Computer Integrated Manufacturing in the Chemical Industry: Theory & Practice
9508	A. Mountford	Can a Brain Drain be Good for Growth?
9509	F. de Roon and C. Veld	Announcement Effects of Convertible Bond Loans Versus Warrant-Bond Loans: An Empirical Analysis for the Dutch Market
9510	P.H. Franses and M. McAleer	Testing Nested and Non-Nested Periodically Integrated Autoregressive Models
9511	R.M.W.J. Beetsma	The Political Economy of a Changing Population
9512	V. Kriman and R.Y. Rubinstein	Polynomial Time Algorithms for Estimation of Rare Events in Queueing Models
9513	J.P.C. Kleijnen, and R.Y. Rubinstein	Optimization and Sensitivity Analysis of Computer Simulation Models by the Score Function Method
9514	R.D. van der Mei	Polling Systems with Markovian Server Routing
9515	M. Das	Extensions of the Ordered Response Model Applied to Consumer Valuation of New Products
9516	P.W.J. De Bijl	Entry Deterrence and Signaling in Markets for Search Goods
9517	G. Koop, J. Osiewalski and M.F.J. Steel	The Components of Output Growth: A Cross-Country Analysis

No.	Author(s)	Title
9518	J. Suijs, H. Hamers and S. Tijs	On Consistency of Reward Allocation Rules in Sequencing Situations
9519	R.F. Hartl and P.M. Kort	Optimal Input Substitution of a Firm Facing an Environmental Constraint
9520	A. Lejour	Cooperative and Competitive Policies in the EU: The European Siamese Twin?
9521	H.A. Keuzenkamp	The Econometrics of the Holy Grail: A Critique
9522	E. van der Heijden	Opinions concerning Pension Systems. An Analysis of Dutch Survey Data
9523	P. Bossaerts and P. Hillion	Local Parametric Analysis of Hedging in Discrete Time
9524	S. Hochgürtel, R. Alessie and A. van Soest	Household Portfolio Allocation in the Netherlands: Saving Accounts versus Stocks and Bonds
9525	C. Fernandez, J. Osiewalski and M.F.J. Steel	Inference Robustness in Multivariate Models with a Scale Parameter
9526	G.-J. Otten, P. Borm, T. Storcken and S. Tijs	Decomposable Effectivity Functions
9527	M. Lettau and H. Uhlig	Rule of Thumb and Dynamic Programming
9528	F. van Megen, P. Borm, and S. Tijs	A Perfectness Concept for Multicriteria Games
9529	H. Hamers	On the Concavity of Delivery Games
9530	V. Bhaskar	On the Generic Instability of Mixed Strategies in Asymmetric Contests
9531	E. Canton	Efficiency Wages and the Business Cycle
9532	J.J.G. Lemmen and S.C.W. Eijffinger	Financial Integration in Europe: Evidence from Euler Equation Tests
9533	P.W.J. De Bijl	Strategic Delegation of Responsibility in Competing Firms
9534	F. de Jong and T. Nijman	High Frequency Analysis of Lead-Lag Relationships Between Financial Markets
9535	B. Dutta, A. van den Nouweland and S. Tijs	Link Formation in Cooperative Situations
9536	B. Bensaid and O. Jeanne	The Instability of Fixed Exchange Rate Systems when Raising the Nominal Interest Rate is Costly

No.	Author(s)	Title
9537	E.C.M. van der Heijden, J.H.M. Nelissen and H.A.A. Verbon	Altruism and Fairness in a Public Pension System
9538	L. Meijdam and H.A.A. Verbon	Aging and Public Pensions in an Overlapping-Generations Model
9539	H. Huizinga	International Trade and Migration in the Presence of Sector-Specific Labor Quality Pricing Distortions
9540	J. Miller	A Comment on Holmlund & Lindén's "Job Matching, Temporary Public Employment, and Unemployment"
9541	H. Huizinga	Taxation and the Transfer of Technology by Multinational Firms
9542	J.P.C. Kleijnen	Statistical Validation of Simulation Models: A Case Study
9543	H.L.F. de Groot and A.B.T.M. van Schaik	Relative Convergence in a Dual Economy with Tradeable and Non-Tradeable Goods
9544	C. Dustmann and A. van Soest	Generalized Switching Regression Analysis of Private and Public Sector Wage Structures in Germany
9545	C. Kilby	Supervision and Performance: The Case of World Bank Projects
9546	G.W.J. Hendrikse and C.P. Veerman	Marketing Cooperatives and Financial Structure
9547	R.M.W.J. Beetsma and A.L. Bovenberg	Designing Fiscal and Monetary Institutions in a Second-Best World
9548	R. Strausz	Collusion and Renegotiation in a Principal-Supervisor-Agent Relationship
9549	F. Verboven	Localized Competition, Multimarket Operation and Collusive Behavior
9550	R.C. Douven and J.C. Engwerda	Properties of *N*-person Axiomatic Bargaining Solutions if the Pareto Frontier is Twice Differentiable and Strictly Concave
9551	J.C. Engwerda and A.J.T.M. Weeren	The Open-Loop Nash Equilibrium in LQ-Games Revisited
9552	M. Das and A. van Soest	Expected and Realized Income Changes: Evidence from the Dutch Socio-Economic Panel
9553	J. Suijs	On Incentive Compatibility and Budget Balancedness in Public Decision Making
9554	M. Lettau and H. Uhlig	Can Habit Formation be Reconciled with Business Cycle Facts?

No.	Author(s)	Title
9555	F.H. Page and M.H. Wooders	The Partnered Core of an Economy
9556	J. Stennek	Competition Reduces X-Inefficiency. A Note on a Limited Liability Mechanism
9557	K. Aardal and S. van Hoesel	Polyhedral Techniques in Combinatorial Optimization
9558	R.M.W.J. Beetsma and A.L. Bovenberg	Designing Fiscal and Monetary Institutions for a European Monetary Union
9559	R.M.W.J. Beetsma and A.L. Bovenberg	Monetary Union without Fiscal Coordination May Discipline Policymakers
9560	R. Strausz	Delegation of Monitoring in a Principal-Agent Relationship
9561	A. Lejour	Social Insurance and the Completion of the Internal Market
9562	J. Bouckaert	Monopolistic Competition with a Mail Order Business
9563	H. Haller	Household Decisions and Equilibrium Efficiency
9564	T. Chou and H. Haller	The Division of Profit in Sequential Innovation Reconsidered
9565	A. Blume	Learning, Experimentation, and Long-Run Behavior in Games
9566	H. Uhlig	Transition and Financial Collapse
9567	R.C.H. Cheng and J.P.C. Kleijnen	Optimal Design of Simulation Experiments with Nearly Saturated Queues
9568	M.F.J. Steel	Posterior Analysis of Stochastic Volatility Models with Flexible Tails
9569	M.P. Berg	Age-Dependent Failure Modelling: A Hazard-Function Approach
9570	F. Verboven	Testing for Monopoly Power when Products are Differentiated in Quality
9571	B. Melenberg and A. van Soest	Semiparametric Estimation of Equivalence Scales Using Subjective Information
9572	J. Stennek	Consumer's Welfare and Change in Stochastic Partial-Equilibrium Price
9573	E. van Damme	Game Theory: The Next Stage
9574	B. Gupta	Collusion in the Indian Tea Industry in the Great Depression: An Analysis of Panel Data

No.	Author(s)	Title
9575	A.B.T.M. van Schaik and H.L.F. de Groot	Unemployment and Endogenous Growth
9576	A.J.T.M. Weeren, J.M. Schumacher and J.C. Engwerda	Coordination in Continuously Repeated Games
9577	A. van den Nouweland, S. Tijs and M. Wooders	Axiomatizations of Lindahl and Ratio Equilibria in Public Good Economies
9578	Richard F. Hartl and Peter M. Kort	Capital Accumulation of a Firm Facing an Emissions Tax
9579	S. Eijffinger and E. Schaling	Optimal Commitment in an Open Economy: Credibility Vs. Flexibility
9580	Willem J.H. Van Groenendaal	Estimating Net Present Value Variability for Deterministic Models
9581	M. Perry and P.J. Reny	A General Solution to King Solomon's Dilemma
9582	H. Huizinga and S.B. Nielsen	Capital Income and Profits Taxation with Foreign Ownership of Firms
9583	T. Berglund and R. Kabir	What Explains the Difference Between the Futures' Price and its "Fair" Value? Evidence from the European Options Exchange
9584	F. Janssen, T. de Kok and F. van der Duyn Schouten	Approximations for the Delivery Splitting Model
9585	E. Canton	Labour Supply Shocks and Neoclassical Theory
9586	E. Ley, M. Steel	A Model of Management Teams
9587	S. Eijffinger, J. de Haan	The Political Economy of Central Bank Independence
9588	J. Suijs, P. Borm, A. De Waegenaere, S. Tijs	Cooperative games with stochastic payoffs
9589	J. Ziliak and T. Kniesner	Estimating Life-Cycle Labor Tax Effects

P.O. BOX 90153, 5000 LE TILBURG, THE NETHERLANDS