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Labor Supply Responses to the 1990s Japanese Tax Reforms

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Abstract

The consumption-leisure choice model implies that an exogenous change in tax rates will induce a change in labor supply. This implication is expected to be important to labor supplied by secondary earners under a progressive tax system when spousal income alters effective marginal tax rates. This paper examines labor supply responses to the income tax changes associated with Japanese tax reforms during the 1990s. The results indicate that the hours-of-work elasticity with respect to the net-of-tax rate is 0.8 for married women.

Keywords: labor supply elasticity, intertemporal labor supply, sample-selection correction model, quasi-experiment, tax reforms

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1 Introduction

Consumer theory implies that an exogenous shift in the budget constraint will induce a change in labor supply. Such a shift can occur by tax changes. Tax reform often alters incentives faced by individuals and thus may alter their work effort. Behavioral responses to tax changes determine not only the relevance of economic theory but also the deadweight loss of taxation and government revenue. Estimating labor supply responses to tax rate changes is indeed one of the central issues in empirical labor economics and public finance.

During Japan's so-called lost decade of the 1990s, the government implemented various income tax cuts as a policy to stimulate the economy and as a by-product of political compromise to introduce and subsequently to increase the consumption tax in Japan. As in many countries, Japan maintains a progressive tax system, under which marginal tax rates go up in a stepwise fashion as income increases. On the one hand, the cross-sectional variation in tax rates itself is not considered exogenous because tax rates can vary according to hours of work. On the other hand, when tax reform is implemented, a change in the tax schedule can generate a plausibly exogenous cross-sectional variation in tax rates over time. A series of Japanese tax reforms during the 1990s provides a good opportunity to identify the labor supply responses to tax rate changes.

Married women are most likely to be affected by Japanese tax reforms among all demographic groups for several reasons. First, the literature suggests that male labor supply responses are zero or small whereas female labor supply responses are measurable and possibly large (Pencavel, 1987; Killingsworth and Heckman, 1987; Blundell and MaCurdy, 1999). Second, female labor supply is low in their late 20s and early 30s, and many married women work part time in their late 30s and 40s in Japan, whereas prime-age male labor supply is highly stable over the life cycle. Finally, there is the "spouse allowance" system in Japan, which makes secondary earners in households more susceptible to the effect of income tax. Under this system, households with low-income secondary earners are eligible for greater tax deductions; thus, there has been serious concern that married women work less and adjust their income so that the spouse allowance will not decrease.

This paper provides the first estimate of labor supply responses in Japan to the changes in tax rates associated with a series of tax reforms using the Japanese Panel Survey of Consumers (JPSC). The spouse allowance system also provides a useful source of variation in tax rates. A

life-cycle model of labor supply is used to analyze the impact of tax reforms. After deriving an intertemporal labor supply function, a simple solution is developed to solve the selection problem in employment for the panel data model with endogenous regressors. An important advantage of the approach here is that it can flexibly allow for the unobserved heterogeneity that may be correlated with the regressors.

The next section presents an intertemporal optimization problem and derives an estimable form of the intertemporal labor supply function. Section 3 discusses the econometric problems that can arise in estimating the labor supply model. Section 4 describes the key features of the Japanese tax system and the 1990s tax reforms. Section 5 describes the panel data used in the analysis. Section 6 presents the empirical results. The final section provides a conclusion.

2 Theoretical Framework

2.1 The model

Quasi-experimental studies typically use a static consumption-leisure choice model as theoretical framework to analyze the impact of tax reforms on labor supply (Eissa and Liebman, 1996; Moffitt and Wilhelm, 2000; Meyer and Rosenbaum, 2001; and Eissa and Hoynes, 2004).[1] Eissa and Hoynes (2004) describe explicitly a unitary household model in which the primary and secondary earners sequentially decide hours of work. This study considers a dynamic model of consumption and labor supply with uncertainty, although the assumption that married women are secondary earners who make their labor supply decisions conditional on their husband's income is maintained here, too, in order to exploit the variation in tax rates from the spouse allowance system in the empirical analysis. Recently, Blundell, Chiappori, Magnac, and Meghir (2007) have developed the collective model of household labor supply in which male labor supply is discrete and female labor supply is continuous and possibly censored. The extension of the collective labor supply model to an intertemporal framework is, however, left for future work. Moreover, the assumption of sequential decision making made here seems a fair approximation of the actual decision process

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[1]See also Moffitt and Kehrer (1981) and Pencavel (1986) for experimental studies on the US negative income tax programs in the late 1960s and 1970s.

because more than 95% of observations in the JPSC sample are couples in which the husband works full time and the husband's earnings are greater than or equal to the wife's earnings.

The conceptual framework adopted here is the intertemporal model of labor supply à la Heckman and MaCurdy (1980) and MaCurdy (1981, 1985). The model involves uncertainty because most tax reforms are best described as once-and-for-all unanticipated shifts in net-of-tax wages in the present and the future, as noted by Blundell and MaCurdy (1999). Denote by $\mathbb{E}_t$ the expectation operator conditional on an information set in period t. Assuming that preferences are additively separable over time and between consumption and leisure, the intertemporal optimization problem faced by married women is to maximize the expected value of the discounted sum of total utility:

$$\mathbb{E}_0 \sum_{t=0}^{T} (1+\rho)^{-t} \left[u^c \left(c_t, s_{1t} \right) + u^h \left(h_t, s_{2t} \right) \right] \tag{1}$$

subject to the budget constraint:

$$a_{t+1} = (1 + r_{t+1}) a_t + (1 - \tau_t) w_t h_t - c_t - p_t q_t, \tag{2}$$

where ρ represents the rate of time preference, c is the consumption, h is the number of hours worked, s_1 and s_2 are preference shifters, a is the asset, r is the net-of-tax real rate of return on assets, w is the hourly wage rate, τ is the effective marginal tax rate, p is an indicator that equals one if the number of hours worked is positive and equals zero otherwise, and q is fixed costs of work.

A dynamic programming formulation of this problem provides a convenient framework for characterizing optimal consumption and hours decisions. Define $V(a_t, s_t)$ as the optimum value of the consumption-leisure choice problem given information up to period t. The value function satisfies the Bellman equation:

$$V(a_t, s_t) = \max \left[u^c \left(c_t, s_{1t} \right) + u^h \left(h_t, s_{2t} \right) + \frac{1}{1+\rho} \mathbb{E}_t V(a_{t+1}, s_{t+1}) \right], \tag{3}$$

where s includes all relevant state variables.

The optimal solution can then be characterized by first-order conditions for consumption and

3

hours, together with an intertemporal condition for the marginal utility of wealth in period t:

$$u_c^c (c_t, s_{1t}) = \lambda_t, \tag{4a}$$

$$u_h^h (h_t, s_{2t}) \geq -\lambda_t \omega_t, \tag{4b}$$

$$\lambda_t = \frac{1 + r_{t+1}}{1 + \rho} \mathbb{E}_t \lambda_{t+1}, \tag{4c}$$

where ω is the after-tax wage rate, and λ is the Lagrange multiplier associated with the budget constraint. The derivation uses the result that the Lagrange multiplier equals the marginal utility of wealth by the Envelop theorem. Equations (4a) and (4b) can be solved for consumption and hours in terms of ω, λ, s_1 and s_2 in the current period. The marginal utility of wealth (λ) serves as the sufficient statistic that captures all information from other periods that is needed to solve the current-period maximization problem. The implied solution for hours is referred to as the Frisch (or λ-constant) labor supply function.

To derive an estimable form of the labor supply function, consider the most popular parametric form in the analysis of intertemporal labor supply. While the instantaneous utility of consumption can remain unspecified, the utility of leisure is specified as an isoelastic function that exhibits constant relative risk aversion (CRRA) as follows:

$$u^h (h_t, s_{2t}) = -\exp\left(-\frac{f + \delta k_t + v_t}{\sigma}\right) \cdot \frac{1}{1 + \frac{1}{\sigma}} h_t^{1 + \frac{1}{\sigma}}, \tag{5}$$

where f is the time-constant unobserved taste heterogeneity, k is the number of young children, and v is an idiosyncratic preference shock.[2] Although the implied solution conveniently helps the interpretation of the model, the isoelastic function excludes a corner solution. Given the fact that some married women are not employed, to allow for a corner solution, consider an exponential function that exhibits constant absolute risk aversion (CARA) as follows:

$$u^h (h_t, s_{2t}) = -\exp\left(-\frac{f + \delta k_t + v_t}{\alpha}\right) \cdot \alpha \exp\left(\frac{h_t}{\alpha}\right), \tag{6}$$

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[2]Age and its square can also be included as taste shifters, but the estimating equation derived below remains essentially unchanged.

In the presence of uncertainty, the marginal utility of wealth can be written as:

$$\ln \lambda_t = \mathbb{E}_{t-1} \ln \lambda_t + \epsilon_t, \tag{7}$$

where ϵ is the forecast error. The Euler equation (4c) can then be rearranged as:

$$\ln \lambda_t = \phi_t + \ln \lambda_{t-1} + \epsilon_t, \tag{8}$$

where $\phi_t = \ln \frac{1+\rho}{1+r_t} - \ln \left(\mathbb{E}_{t-1} \exp \left(\epsilon_t \right) \right)$.[3] The ϕ term can be captured by a common macroeconomic effect if ϵ is identically distributed across individuals. Substituting backward in (8) yields

$$\ln \lambda_t = \sum_{\iota=1}^{t} \phi_\iota + \ln \lambda_0 + \sum_{\iota=1}^{t} \epsilon_\iota. \tag{9}$$

That is, the λ term can be captured by a time effect that is common across individuals and a fixed effect that can vary across individuals. The forecast error can be decomposed as:

$$\epsilon_t = \gamma \triangle \ln \omega_t + \xi_t, \tag{10}$$

where ξ is a stochastic error component orthogonal to changes in the after-tax wage rate. The parameter γ represents the wealth effect because of unexpected wage changes and thus must be non-positive.

The wage equation is specified in a way that is consistent with standard human capital models. The lifetime wage path can be described by:

$$\ln w_t = a + \vartheta t + \frac{\theta}{2} t^2 + \zeta_t, \tag{11}$$

where a is the time-constant unobserved heterogeneity in productivity, and ζ is a idiosyncratic productivity shock. The life-cycle wage profile is typically increasing and concave. In that case, $\vartheta \geq 0$ and $\theta \leq 0$.

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[3]Equation (7) can be written as $\lambda_t = \exp \left(\mathbb{E}_{t-1} \ln \lambda_t \right) \exp \left(\epsilon_t \right)$. Taking expectations yields $\mathbb{E}_{t-1} \lambda_t = \exp \left(\mathbb{E}_{t-1} \ln \lambda_t \right) \mathbb{E}_{t-1} \exp \left(\epsilon_t \right)$, or equivalently, $\exp \left(\mathbb{E}_{t-1} \ln \lambda_t \right) = \frac{\mathbb{E}_{t-1} \lambda_t}{\mathbb{E}_{t-1} \exp (\epsilon_t)}$. Thus, $\lambda_t = \mathbb{E}_{t-1} \lambda_t \frac{\exp(\epsilon_t)}{\mathbb{E}_{t-1} \exp(\epsilon_t)}$. The Euler equation (4c) in period $t-1$ can be rewritten as $\mathbb{E}_{t-1} \lambda_t = \frac{1+\rho}{1+r_t} \lambda_{t-1}$. Hence, $\lambda_t = \frac{1+\rho}{1+r_t} \lambda_{t-1} \frac{\exp(\epsilon_t)}{\mathbb{E}_{t-1} \exp(\epsilon_t)}$.

Assuming the interior solution in the case of CRRA preferences, the conditions (4b) and (9) lead to the Frisch labor supply function:

$$\ln h_t = (f + \sigma \ln \lambda_0) + \sigma \ln \omega_t + \delta k_t + \sigma \sum_{\iota=1}^{t} \phi_\iota + \left(v_t + \sigma \sum_{\iota=1}^{t} \epsilon_\iota \right). \tag{12}$$

This equation implies that, first, hours of work are longer at the points of the life cycle when wages are high. Second, hours of work can vary with taste shifters such as the number of children. Finally, under the assumption that ϕ is constant over time, hours of work decline over the life cycle, if the rate of time preference is lower than the real rate of return on assets. Other things being equal, hours of work will be longer in a period of deflation and shorter in a period of inflation. It should be noted, however, that the wage rate and the interest rate vary concurrently according to macroeconomic conditions. Disentangling the two effects on labor supply in aggregate data is thus difficult. Micro data are generally needed to identify the labor supply elasticity.

The wage coefficient is the Frisch elasticity which measures labor supply responses to evolutionary wage changes along the lifetime wage profile. The Frisch elasticity is known to be the upper bound of the Hicksian elasticity, which is greater than the Marshallian elasticity when leisure is a normal good.[4] Moreover, the Frisch elasticity can overstate the impact of tax reforms because it ignores the unexpected shift in wealth from a once-and-for-all change in net-of-tax wages, as noted by Blundell and MaCurdy (1999).

The labor supply elasticity will not be consistently estimated when ordinary least squares (OLS) is simply applied on equation (12) because λ_0 is unobserved but correlated with all wages over the life cycle. When panel data are available, the marginal utility of wealth (λ_0) and the persistent preference heterogeneity (f) can be eliminated by taking a first difference. Substituting the forecast error (10) and the wage equation (11) into the first-difference equation of the Frisch labor

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[4]Consider a static optimization problem in which an individual maximizes a CRRA utility function: $u(c, h, s_1, s_2) = g(s_1) \frac{1}{1+\frac{1}{\eta}} c^{1+\frac{1}{\eta}} - g(s_2) \cdot \frac{1}{1+\frac{1}{\sigma}} h^{1+\frac{1}{\sigma}}$ for $\eta \leq 0$ and $\sigma \geq 0$, where $g(\cdot)$ is an unknown function, subject to the budget constraint: $c = \omega h + y$. Taking the derivative of the utility function with respect to h after substituting the budget constraint leads to the first-order condition: $g(n) h^{\frac{1}{\sigma}} = \omega (\omega h + y)^{\frac{1}{\eta}}$. This optimality condition implies that the Marshallian elasticity is $\varepsilon_m \equiv \frac{\partial h}{\partial \omega} \frac{\omega}{h}\big|_y = \frac{\sigma[(1+\eta)\omega h+\eta y]}{(\eta-\sigma)\omega h+\eta y}$ and that the income elasticity is $\varepsilon_y \equiv \frac{\partial h}{\partial y} \frac{y}{h}\big|_\omega = \frac{\sigma y}{(\eta-\sigma)\omega h+\eta y}$. By the Slutsky equation, the Hicksian elasticity is $\varepsilon_h \equiv \frac{\partial h}{\partial \omega} \frac{\omega}{h}\big|_u = \varepsilon_m - \frac{\omega h}{y}\varepsilon_y = \frac{\sigma\eta(\omega h+y)}{(\eta-\sigma)\omega h+\eta y}$. The Hicksian elasticity is greater than the Marshallian elasticity when leisure is a normal good. As seen above, the Frisch elasticity is $\varepsilon_f = \frac{\partial h}{\partial \omega} \frac{\omega}{h}\big|_\lambda = \sigma$, which is greater than or equal to the Hicksian elasticity. Therefore, $\varepsilon_m \leq \varepsilon_h \leq \varepsilon_f$.

supply (12) yields:

$$\triangle \ln h_t = (\sigma + \mu) \triangle \ln (1 - \tau_t) + \triangle x_t \pi + \triangle e_t, \tag{13}$$

where $\triangle$ represents the change in each variable between the two adjacent periods, $\mu = \sigma \gamma$, $\triangle x_t \pi = (\sigma + \mu)(\vartheta - \theta/2) + \delta \triangle k_t + (\sigma + \mu) \theta t + \sigma \phi_t$, and $\triangle e_t = \triangle v_t + (\sigma + \mu) \triangle \zeta_t + \sigma \xi_t$. The coefficient on the log of net-of-tax rate $(\sigma + \mu)$ is the policy-relevant elasticity that accounts for labor supply responses to parametric shifts in the lifetime wage profile. Again, cross-sectional variation in tax rates over time is required to identify the labor supply elasticity.

Under the CARA preferences, the Frisch labor supply function can be derived as:

$$\triangle h_t = \begin{cases} (\alpha + \mu) \triangle \ln (1 - \tau_t) + \triangle x_t \pi + \triangle e_t & \text{if she works,} \\ 0 & \text{otherwise.} \end{cases} \tag{14}$$

where $\mu = \alpha \gamma$, $\triangle x_t \pi = (\alpha + \mu)(\vartheta - \theta/2) + \delta \triangle k_t + (\alpha + \mu) \theta t + \alpha \phi_t$, and $\triangle e_t = \triangle v_t + (\alpha + \mu) \triangle \zeta_t + \alpha \xi_t$. The policy-relevant elasticity can be calculated by $(\alpha + \mu)/\overline{h}$, where $\overline{h}$ is the sample mean of hours worked among the employed.

2.2 Fixed costs of work

In the presence of fixed costs, labor market participation does not simply follow the corner-solution condition, as noted by Blundell, MaCurdy, and Meghir (2007). Instead, participation depends not only on the determinants of hours worked but also on the components of fixed costs, such as transportation costs, child care costs, and job search costs that can vary by family structure and by region. The decision to work follows from

$$V^1 \geq V^0 \tag{15}$$

where:

$$V^1 = \max \left[\begin{array}{c} u^c\left(c_t, s_{1t}\right) + u^h\left(h_t, s_{2t}\right) \\ +\frac{1}{1+\rho}\mathbb{E}_t V\left((1+r_{t+1})\,a_t + (1-\tau_t)\,w_t h_t - c_t - q_t, s_{t+1}\right) \end{array} \right], \quad (16a)$$

$$V^0 = \max \left[u^c\left(c_t, s_{1t}\right) + u^h\left(0_t, s_{2t}\right) + \frac{1}{1+\rho}\mathbb{E}_t V\left((1+r_{t+1})\,a_t - c_t, s_{t+1}\right) \right]. \quad (16b)$$

The participation condition implies that higher fixed costs decrease the value of, and lower the probability of, working.

3   Econometric Issues

3.1   Instrumental variable method

Solving the lifetime utility maximization problem among the participants results in the first-difference version of the Frisch labor supply function (14), where the dependent variable is change in hours of work and the explanatory variables include change in the log of net-of-tax rate, age, year dummies, and change in the number of children.[5] Age can be replaced with change in age squared. The error term consists of idiosyncratic shocks in preferences, productivity, and forecast error and thus may be heteroscedastic and serially correlated. Moreover, the error term may be correlated with cross-sectional variation in the actual tax rates over time. Because the changes in tax rates are associated with previous earnings, some of the variation can reflect labor supply responses to tax reforms.[6] The first-difference estimator, which is also known as the difference-in-differences estimator,[7] will not be consistent. In the presence of mean reversion, the change in hours of work should be larger for workers who experienced a negative temporary shock in the previous year. The estimated labor supply elasticity will then be biased downward. To circumvent this problem, the approach proposed by Auten and Carroll (1999) and Gruber and Saez (2002) is used here.

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[5] The constant term is redundant conditional on year dummies.

[6] This problem is similar to the one that arises in experimental studies of negative income tax programs (Keeley and Robins, 1980; Moffitt and Kehrer, 1981).

[7] Hall (1975, p. 127) presents a difference-in-differences approach to control for aggregate macroeconomic effects in examining the impact of negative income tax programs.

To control for mean reversion, the lagged hours of work is first incorporated as an additional regressor into the hours-of-work equation (14):

$$\triangle h_{it} = \beta \triangle \ln (1 - \tau_{it}) + \triangle x_{it} \pi + g(h_{i,t-1}) + \triangle e_{1it} \qquad \text{for } p_{it} = p_{i,t-1} = 1, \qquad (17)$$

where x is the vector of observed attributes that includes the number of children under the age of seven before compulsory education, the number of children aged seven to 15 during compulsory education, age-squared, and year dummies, e_1 is the error term, p is an indicator that equals one if the individual is employed and equals zero if she is a full-time housewife, i is an index for individuals, and t is an index for year hereafter. The labor supply responses to tax rates are denoted by β. To mitigate the bias arising from mean reversion, the effect of lagged hours of work is nonparametrically specified. In practice, the unknown function $g(\cdot)$ is approximated by fifth-order polynomials. After making the exclusion restrictions tenable, the instrumental variable approach is applied to equation (17). The instrument used here is constructed in a way that rules out the variation in tax rates arising from behavioral responses.

$$z_{1it} = (1 - \widetilde{\tau}_{it}) - (1 - \tau_{i,t-1}) = \tau_{i,t-1} - \widetilde{\tau}_{it}, \qquad (18)$$

where $\widetilde{\tau}$ represents the net-of-tax rate calculated from the previous taxable income at year $t - 1$ under the current tax system at year t. In other words, $\widetilde{\tau}$ is the effective tax rate if the tax schedule alone changes. Thus, the instrument (z_1) indicates how the net-of-tax rate would change in response to tax reforms without behavioral responses. The reduced-form equation for the change in the log of net-of-tax rate can be described by:

$$\triangle \ln (1 - \tau_{it}) = \kappa_1 z_{1it} + \triangle x_{it} \kappa_2 + g(h_{i,t-1}) + \triangle e_{2it}, \qquad (19)$$

where $\triangle e_{2it}$ is the error term.

3.2 Sample-selection correction method

A potential problem with the approach above is the composition change of labor market partici-
pants. The estimated labor supply responses may suffer from a selection bias if the composition
effects are not fully captured by an individual fixed effect, a time effect, and other observed at-
tributes. To correct for the potential selection bias, a simple panel-data model with an endogenous
regressor is developed here, building upon the sample-selection correction model proposed by
Olsen (1980).

We assume that the participation condition (15) can be approximated by an index function in a
linear form:

$$p_{it} = z_{2it}\kappa_3 + x_{it}\kappa_4 + a_i + e_{3it}, \tag{20}$$

where z_2 is fixed costs that vary by regional labor market conditions, a is an individual fixed effect,
and e_3 is the error term. The regional labor market conditions are specified as the interaction terms
between 47 prefectural dummies and nine year dummies. This specification is motivated by the fact
that fixed costs, such as commuting costs, child care costs, and job search costs, vary across regions
over time. The idea to use the regional labor market conditions as excluded instruments is similar
to the one proposed by Blundell, Ham, and Meghir (1987). By virtue of linear specification, the
time-invariant unobserved heterogeneity can be eliminated after the first-difference transformation:

$$\triangle p_{it} = z_{2it}\kappa_3 + \triangle x_{it}\kappa_4 + \triangle e_{3it}, \tag{21}$$

For identification and estimation, the following set of assumptions is imposed on the model
presented above: (a) (p, x, z_2) is always observed, whereas (h, τ, z_1) is observed when $p = 1$. (b)
$\mathbb{E}\left[\triangle e_3 | \triangle Z\right] = \mathbb{E}\left[\triangle e_3 | \triangle Z_2\right] = 0$, where $\triangle Z = (z_1, z_2, \triangle x, g\left(h_{i,t-1}\right))$ and $\triangle Z_2 = (z_2, \triangle x)$;
(c) $\kappa_3 \neq 0$; (d) $\mathbb{E}\left[\triangle e_1 | \triangle e_3, \triangle Z\right] = \mathbb{E}\left[\triangle e_1 | \triangle e_3\right] = \psi \triangle e_3$; (e) e_3 has a uniform distrib-
ution; (f) $\mathbb{E}\left[\triangle e_1 | \triangle Z\right] = 0$; (g) $\kappa_1 \neq 0$; (h) $\mathbb{E}\left[\triangle e_2 | \triangle Z\right] = \mathbb{E}\left[\triangle e_2 | \triangle Z_1\right]$, where $\triangle Z_1 = (z_1, \triangle x, g\left(h_{i,t-1}\right))$.

Assumption (a) states the observational rule. Assumption (b) is necessary to estimate consis-

tently the selection equation (20). Assumption (c) is the rank condition for excluded instruments. The exclusion restriction is crucial for identification, as the sample-selection correction term is a linear function. In other words, the sample-selection correction term is linearly dependent on the other explanatory variables in the absence of an excluded instrument in the selection equation; thus, the parameter ψ is not identifiable. Assumption (g) requires the excluded instrument, which is the predicted change in net-of-tax rates assuming that income remains the same as in the base year, to be correlated with the log of net-of-tax rate.

Under assumptions (d), (e), and (f), it follows that $\mathbb{E}\left[\triangle e_{1it} \mid \triangle Z_{it}, p_{it} = p_{i,t-1} = 1\right] = \psi \triangle e_{3it}$.[8] Under the additional assumption (h), the hours-of-work equation can be rewritten as:

$$
\begin{aligned}
\mathbb{E}\left[\triangle h_{it} \mid \triangle Z_{it}, p_{it} = p_{i,t-1} = 1\right] &= \beta \mathbb{E}\left[\triangle \ln\left(1 - \tau_{it}\right) \mid \triangle Z_{1it}, p_{it} = p_{i,t-1} = 1\right] \\
&\quad + \triangle x_{it}\pi + g\left(h_{t-1}\right) + \psi \triangle e_{3it},
\end{aligned}
\tag{22}
$$

where the last term serves as the sample-selection correction term.[9] In practice, the residual term is interacted with the year dummies to allow for the differential effect of sample selection over time. If the estimated coefficients on the selection correction terms differ statistically significantly from zero, the estimation suffers from selection bias in the absence of sample-selection correction terms.

The estimation procedure requires only a linear regression as follows. First, the residual is constructed after a set of parameters (κ_3, κ_4) is consistently estimated via OLS regression of (21). Then, the instrumental variable method is applied to estimate equation (22), where the residual constructed in the first step is included as the selection correction term, and a set of parameters (β, π, ψ) is consistently estimated. Alternatively, instead of the instrumental variable method, OLS can be applied to the first-difference equation of (17) after the selection correction terms and the residual constructed from the OLS regression of (19) in the presence of the sample-selection correction terms are incorporated as additional regressors. The standard errors are computed using a block bootstrap technique in which the sampling unit is an individual to allow for heteroscedasticity and serial correlation.

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[8]The derivation does not rely on the assumption that the error terms are jointly normally distributed.
[9]Card (1990) employs essentially the same approach.

Importantly, the sample-selection correction model developed here can allow for an arbitrary correlation between regressors and unobserved heterogeneity. As proposed by Semykina and Wooldridge (2005), it is also possible to estimate the selection equation using a probit model under the normality assumption. However, this specification requires the assumption that unobserved heterogeneity can be expressed as a linear projection of observed characteristics. Moreover, our method does not suffer from the incidental parameter problem, unlike the Tobit model analyzed in Heckman and MaCurdy (1980). Another advantage is computational simplicity.

The distributional assumption for the error term appears to be strong, and it may be considered a disadvantage. In general, the drawback of the linear probability model is that the predicted response probability does not necessarily fall within the range between zero and one. However, the estimator is consistent as long as the mean independence assumption, i.e., assumption (b), holds, and the prediction approximately overlaps between the linear probability model and the probit/logit model around the middle of the distribution. Moreover, Newey (1999) shows that the linear sample-selection correction model proposed by Olsen (1980) may provide a consistent estimator under certain conditions placed on regressors, despite its misspecification of the distribution. In other words, the uniform distribution assumption, i.e., assumption (e), is not necessary for consistency, and it can be replaced by the set of conditions presented in Newey (1999). However, this result does not extend to the non-linear sample-selection correction model, where the selection equation is specified as a probit or logit model. Therefore, which parametric assumption is stronger is not definitive.

4   Institutional Background

4.1   Tax basis, deductions, and progressivity

As in many countries, income tax is imposed on individual taxable income, and the labor income tax is progressive in Japan. There are several tax brackets, and marginal tax rates increase by roughly 10% in each bracket. The number of tax brackets was five until 1998 and decreased to four in 1999. The maximum marginal tax rate then decreased from 50% to 37%. Labor income is taxed separately from capital income which is taxed uniformly.

Various tax deductions are permitted in Japan. Some tax deductions such as the allowance for dependents can reduce the taxable income of either the husband or the wife, but not both. Thus, spousal income can affect the marginal tax rate and the amount of tax liability. Moreover, the amount of the spouse allowances varies with spousal income within a certain range of income.[10] The rate of deduction for employment income varies with labor income from 5% to 40% when gross income exceeds 1.65 million yen.

4.2 Spouse allowances

The spouse allowance permits individuals with spouses earning low incomes to deduct an amount of tax liability. More specifically, the sum of the spouse allowance and special spouse allowance, denoted by SA, varies according to the secondary earner's income, denoted by I^S, and is deducted from the primary earner's tax liability as follows:

$$
SA = \begin{cases} SA_{\max} & \text{if } I^S < c_1 & \text{``plateau'',} \\ SA_{\max} - \left(I^S - c_1\right) & \text{if } c_1 \leq I^S < c_2 & \text{``phase-out'',} \\ 0 & \text{if } c_2 \leq I^S, \end{cases} \tag{23}
$$

where $SA_{\max} = 0.7$, $c_1 = 0.65$, and $c_2 = 1.35$ million yen until 1994, and $c_2 = 1.41$ million yen from 1995.[11] The phase-out region is generated by the decrease in the special spouse allowance. The shape of the spouse allowance schedule looks similar to that of the Earned Income Tax Credit (EITC), as illustrated in Figure 1. There is, however, no phase-in region in the spouse allowance system. This implies that the spouse allowance system does not create incentives but only disincentives to work.

Consider a household in which primary and secondary earners share a common budget constraint. The spouse allowance system alters the secondary earner's marginal tax rates as well as the amount of the primary earner's tax liability in the phase-out region, because the deduction amount for the special spouse allowance decreases proportionally with spousal income, as noted by Akabayashi (2006). Figure 2 shows that the effective marginal tax rates of the secondary earner

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[10]There is basically no variation in effective tax rates for those who have no individual labor income when individual income is taxed separately from spousal income, and when labor income is taxed separately from capital income.

[11]The exchange rate of the Japanese yen to the US dollar ranged from 94 to 131 yen between 1993 and 1999.

fall into four categories after spouse allowances are taken into account. The plateau region corresponds to the first income range, the phase-out region corresponds to the second and third income ranges, and there is no spouse allowance in the fourth income range. Thus, the effective marginal tax rate equals the secondary earner's own rate in the first and last income ranges. In contrast, in the second and third income ranges, the effective marginal tax rate faced by the secondary earner equals her own marginal tax rate plus the primary earner's marginal tax rate, because the sum of the spouse allowance and the special spouse allowance decreases at the same rate as income increases.[12] Although the basic allowance and the deduction for employment income lower the individual tax liability to zero in the first and second income ranges, the effective marginal tax rate of the secondary earner is not zero but her husband's marginal tax rate in the second range. The second and third categories of annual income ranged from 0.7 to 1 million yen and from 1 to 1.35 million yen, respectively, until 1994, and from 0.7 to 1.03 million yen and from 1.03 to 1.41 million yen, respectively, after 1995. The first and last categories are outside these intervals.

4.3 The 1990s tax reforms

Five reductions in income tax were implemented during the 1990s, as summarized in Table 1. In fact, a series of Japanese tax reforms in the 1990s significantly altered the marginal tax rate for many people. No tax reform relevant to this study was implemented between 2000 and 2002. The structure of the income tax cuts varied in each case. Of the five tax cuts, two were permanent, two were temporary, and one included both permanent and temporary cuts.

Permanent changes were implemented in three ways. First, the tax brackets were changed in 1994 and reduced in 1999. Second, in 1999 the maximum tax rate was reduced from 50% to 37%. Third, personal tax deductions, such as the basic allowance, the allowance for dependents, the spouse allowance, and the special spouse allowance, were increased by 30 thousand yen in 1995.

Temporary changes were implemented in two ways. First, a 15% or 20% tax refund of the income tax liability, called the special tax cut, was introduced temporarily in 1994, 1995, and 1996. In 1999, a 20% fixed rate tax cut was introduced without a specified time limit. The upper

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[12]However, individuals whose annual taxable incomes are greater than or equal to 10 million yen are not eligible for the special spouse allowance.

limits of the tax refunds in 1994, 1995, and 1996 were 2 million yen, 50 thousand yen, and 50 thousand yen, respectively. Second, in 1998, the fixed amount of income tax refund was made proportional to the number of dependents.[13]

5   Data

Theoretical and econometric issues have been discussed so far on the assumption that panel data are available. The data used in the analysis are from the Japanese Panel Survey of Consumers (JPSC) from 1993 to 2002. A nationwide representative sample of 1,500 women aged 24 to 34 has been surveyed each year since 1993, and 500 women aged 24 to 27 have been surveyed each year since 1997. The analysis of hours worked focuses on married women who report after-tax income for at least two sequential years, along with their husbands, to calculate their tax rates. The appendix provides details on calculating income tax. Respondents are excluded from the sample if there are missing values or clearly inconsistent responses regarding employment status, hours of work, and income. Based on these criteria, the sample consists of 3,070 observations from an unbalanced panel of 659 married women. Full-time housewives are added when estimating the sample-selection correction model, bringing the sample to 7,040 observations from 1,177 married women.

Table 2 summarizes the characteristics of the sample used in the analysis. There is considerable cross-sectional diversity in employment status and industry. The analysis here is not limited to tenured or permanent employees. In particular, 53% of the employed are employed as part-time workers, who can change their hours of work more flexibly. The standard deviation among part-time and temporary workers is indeed 36% higher than that among full-time workers. Moreover, year-to-year variation in the type of employment and industry are commonly observed among married women. During the sample period, 19.6% of the 659 married women changed their employment status one or more times, 31.7% changed their industry one or more times, and 39.9% changed either their employment status or industry one or more times. The JPSC collects informa-

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[13]An interesting question may be whether and how labor supply responses differ in response to permanent and temporary tax changes. One way of testing this question may be to examine the responses to only those tax changes associated with permanent tax reforms. However, the distinction between temporary and permanent changes is not obvious in all cases.

tion about the allocation of time separately for weekdays and weekends. The number of weekly hours worked used in this study is calculated from that information and may be more reliable than the number calculated from retrospective information about annual hours of work. Comparing the employed married women with housewives, the employed married women have slightly low-income husbands and a small number of children under the age of seven. Importantly, 40% of the employed married women are eligible for spouse allowances. Their labor supply behavior may be susceptible to the effect of tax system.

Osano and Inoue (1991) and Beason (1993) raise the question of the applicability of the intertemporal substitution model to the Japanese labor market. Both studies use aggregate data and obtain mixed results. Some of the results in these studies are not in favor of the intertemporal substitution model, but a failure to fit the intertemporal labor supply model can be attributed to the nature of aggregate data, as discussed above. During the sample period from 1993 to 2002, the Japanese economy has been stagnant, which may bring up the same question. Yet, the unemployment rate stayed at 5.4% in 2002, although it increased from 2.4% in 1993, according to OECD statistics. Moreover, this study is designed to better fit the labor supply model to the data. First, the analysis here focuses on married women whose labor supply tends to vary relative to other demographic groups. Second, a series of tax reforms is used to identify labor supply responses. Finally, the demand-side conditions in the labor market are incorporated in the selection equation.

6   Empirical Results

The results reported in columns 1 and 2 of Table 2 are obtained by applying the instrumental variable method to the first-difference equation of (17) using the excluded instrument (18). The results are presented in both the presence and absence of year dummies. In the absence of year dummies, the constant term is included in the covariates. The standard errors and the test statistics reported here are all robust to heteroscedasticity and serial correlation. The parameter estimates obtained here are consistent with the standard results in the literature (Killingsworth and Heckman, 1987). The estimated coefficient on the log of net-of-tax rate suggests a positive and moderately large labor supply response. The effect of income tax on hours of work differs statistically from

zero at the 5% significance level in the absence of year dummies and at the 10% significance level in the presence of year dummies. A 10 percentage point decrease in the marginal tax rate increases hours of work by 2.8 per week. The elasticity with respect to the net-of-tax rate is 0.81 at the sample mean of hours worked. The number of young children decreases hours of work, although the estimated effect is not statistically significant. These results are robust to outliers in hours of work. The joint significance level of the fifth-order polynomials in lagged hours of work is 0.00.

The results reported in column 3 are obtained by implementing the sample-selection correction method developed in the earlier section. In the estimation of the labor market participation equation (21), the F-statistic is 58,13 with a p-value of 0.00 under the null hypothesis that all of the coefficients on the excluded instruments are zero. This means that year-specific regional labor market conditions provide the sample-selection correction terms with independent variation and that the rank condition for identification holds. Then, in the estimation of the hours-of-work equation (22), the χ^2 statistic is 7.84 with a p-value of 0.55 under the hypothesis that all of the coefficients for the sample-selection correction terms are zero, indicating no sample-selection bias. The estimated tax effect is indeed identical to that in column 2.[14]

The correlation between the instrumental variable and the endogenous variable is strong in the first-stage regression of (19). In other words, the changes in effective tax rates are strongly associated with the tax changes arising from tax reforms from columns 4 to 6 of Table 2. The results indicate that tax cuts reduce net-of-tax rates, as expected. Under the hypothesis that the coefficient of the excluded instrument equals zero, the F-statistics are 158 in the absence of year dummies in column 4, 127 in the presence of year dummies in column 5, and 118 in the presence of year dummies and sample-selection correction terms in column 6. The instrument used is strong enough to make an inference for the finite sample.

Finally, given the result that no sample-selection bias can be found, the instrumental variable method is also applied to the first-difference equation in double-log form using the same instrument in Table 3. The estimated parameters obtained in Table 3 are similar to those in Table 2. Overall, the labor supply elasticities range between 0.81 and 0.83 in the presence of year dummies.

The labor supply responses of married men and unmarried women may also be relevant in

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[14]These results hold even after prefectural dummies are added only in z_2 or in both x and z_2.

determining the effects of tax policy. To examine their behavioral responses, the same analysis was conducted separately for married men and unmarried women. This exercise reveals small and highly statistically insignificant elasticities with respect to the net-of-tax rate for both married men and unmarried women. Thus, the labor supply responses of married men and unmarried women to the 1990s tax reforms appear to be negligible.

Labor supply responses to tax rates can vary with the income range. To examine whether the responses to tax reforms are heterogeneous across individuals with different income levels, the same analysis is conducted using subsamples split by income ranges. The results reveal no statistically significant differences between the subsamples. However, in part, this may be because of a reduction of the sample sizes and of variation in tax rates after splitting the sample.

7 Conclusion

The aim of this paper was to examine labor supply responses to tax rate changes. Various tax reforms implemented in Japan during the 1990s were used as quasi-experiments to determine the causal relationship between labor supply and tax rates. Although the effects identified by quasi-experimental studies are considered to be plausible because the source of exogenous variation is transparent, the quasi-experimental approach can be critiqued with regard to the economic interpretations of the estimation results. Thus, an intertemporal model of labor supply was described to clarify the interpretation and identification assumptions. The analysis of panel data using the instrumental variable method and the sample-selection correction method indicates that taxation has non-negligible disincentive effects on labor supply by married women. The findings are consistent with income adjustment behavior by married women who are susceptible to the effect of the spouse allowance system.

Appendix

Calculation of income tax

The marginal tax rates and the amount of tax liability have non-linear relationships with taxable income and the number of dependents. The withholding tax table for monthly salary payments reports the amount of labor income tax liability that corresponds to taxable labor income and the number of dependents. The JPSC collects data on the monthly after-tax incomes of respondents and their husbands, and on the number of children that they have.

Using the tax table and the data set, income tax is calculated as follows. First, the marginal tax rates are calculated from the tax table, after both permanent and temporary tax cuts are taken into account. Second, the after-tax income, which corresponds to the amount of tax liability, is calculated as taxable income less the amount of tax liability from the tax table. Third, the number of dependents for each individual is calculated from the data set. Children and a spouse earning lower than a certain threshold are considered dependents. It is assumed that couples will deduct the dependent allowance from the taxable income of the higher-earning spouse to gain a tax advantage. Fourth, data on the marginal tax rates and the amount of tax liability from the tax table are matched to the JPSC data on after-tax income and the number of dependents. Finally, the spousal marginal tax rates are added to the marginal tax rates, and the amount of spousal tax liability is deducted if the before-tax income falls into the second or third income ranges.

The sample distribution of marginal tax rates is summarized as follows. Among the 3,070 observations of employed women, the effective marginal tax rate is zero for 17.3%, greater than zero but less than 0.1 for 68.8%, greater than or equal to 0.1 but less than 0.2 for 13.8%, and greater than or equal to 0.2 for 0.001%. In fact, the various tax deductions lower the marginal tax rate.

The author recognizes the limitations of calculating income tax from the withholding tax table for monthly salary payment. This table does not account for several tax deductions, such as deductions for life insurance premiums, casualty insurance premiums, and buying a home, which can be claimed as a year-end tax adjustment. However, more accurate approximation is beyond the scope of this paper. The measurement-error problem can be alleviated by the instrumental variable method.

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Table 1: The 1990s Tax Reforms

Year	Description of tax cuts
1994	20% tax refund of the amount of income tax up to 2 million yen
1995	Changes in tax brackets, expansions of various types of deductions, and 15% tax refund of the amount of income tax up to 50,000 yen
1996	15% tax refund of the amount of income tax up to 50,000 yen
1998	Tax refund of 38,000 yen plus 19,000 yen times the number of dependents
1999	Changes in marginal tax rates and 20% cut in the amount of income tax up to 250,000 yen

Table 2: Summary Statistics

Variables	Mean (SD)	Variables	%
Panel A: Employed married women			
Hours of work per week	35.3 (12.4)	Employment status	
Monthly after-tax labor income of		Full-time worker	42.9
Married woman	12.4 (7.6)	Part-time worker	53.2
Her husband	26.8 (9.8)	Temporary worker	3.7
Age	34.0 (4.4)	Non-response	0.2
Number of children		Industry	
Under the age of 7	0.60 (0.78)	Agriculture, forestry, fisheries, mining	1.0
Aged 7 to 15	0.91 (0.93)	Construction	2.4
Aged 16 to 22	0.09 (0.35)	Manufacturing	16.5
Educational background		Wholesale, retail	26.0
Junior high school	2.8	Finance, insurance, real estate	7.5
High school	51.1	Traffic, communication	2.4
Career college	16.2	Electric, gas, water, heat	0.5
Junior or technical college	20.1	Service	27.7
University or graduate school	9.6	Public	15.7
		Others	0.3
Panel B: Housewives			
Monthly after-tax labor income of		Educational background	
Married woman	0.0 (0.0)	Junior high school	5.9
Her husband	30.0 (12.4)	High school	43.0
Age	32.6 (4.0)	Career college	18.2
Number of children		Junior or technical college	21.7
Under the age of 7	1.16 (0.84)	University or graduate school	11.2
Aged 7 to 15	0.59 (0.84)		
Aged 16 to 22	0.03 (0.21)		

Notes: The unit of income is 10,000 yen.

Table 3: First-Difference Instrumental Variable Estimates for Hours of Work

Dependent variable:	Hours of work			log of net-of-tax rate		
Explanatory variables	(1)	(2)	(3)	(4)	(5)	(6)
log of net-of-tax rate	25.9	28.2	28.2	_	_	_
	(12.4)	(14.6)	[13.4]			
Tax reforms	_	_	_	0.75	0.72	0.72
				(0.06)	(0.06)	[0.06]
# children aged 0–6	-0.34	-0.35	-0.27	0.00	0.01	0.01
	(0.64)	(0.65)	[0.67]	(0.00)	(0.00)	[0.00]
# children aged 7–15	-0.04	-0.04	-0.00	0.01	0.01	0.01
	(0.60)	(0.62)	[0.63]	(0.00)	(0.00)	[0.00]
Elasticity	0.74	0.81	0.81	_	_	_
	(0.36)	(0.42)	(0.38)			
Year dummies?	No	Yes	Yes	No	Yes	Yes
Selection correction terms?	No	No	Yes	No	No	Yes

Notes: Standard errors in parentheses and square brackets are clustered at the individual level. Standard errors in square brackets are estimated by block bootstrap. The labor supply elasticity is evaluated at the sample mean of hours of work. Other covariates in the first-difference equation include the constant term, the change in age-squared, and the fifth-order polynomials in lagged hours of work.

Table 4: First-Difference Instrumental Variable Estimates for the log of Hours of Work

Dependent variable:	log of Hours of work	
Explanatory variables	(1)	(2)
log of net-of-tax rate	0.77	0.83
	(0.37)	(0.44)
# children aged 0–6	-0.02	-0.02
	(0.02)	(0.02)
# children aged 7–15	-0.01	-0.01
	(0.02)	(0.02)
Year dummies?	No	Yes

Notes: Standard errors in parentheses are clustered at the individual level. Other covariates in the first-difference equation include the constant term, the change in age-squared, and the fifth-order polynomials in lagged hours of work.
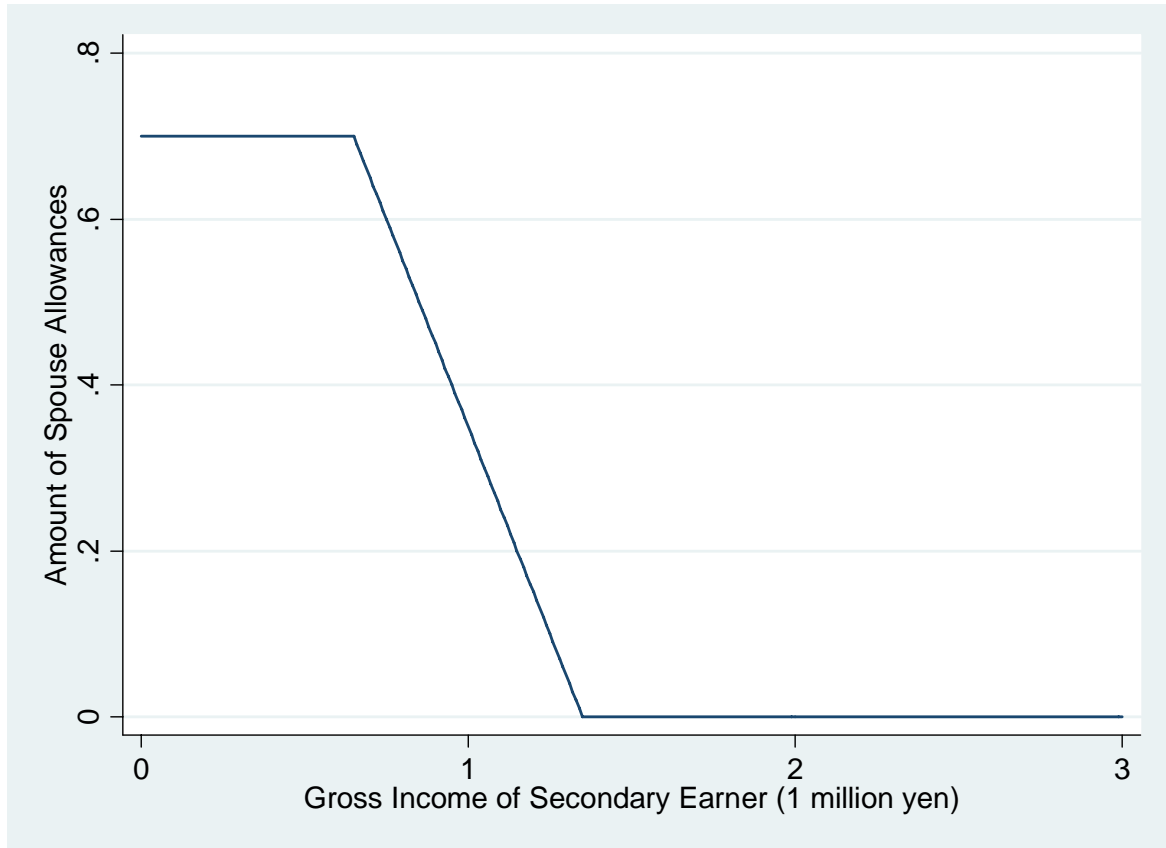
Figure 1: Spouse Allowances

Figure 2: Spouse Allowances and Marginal Tax Rates (MTR)