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The CES Utility Function, Non-linear Budget Constraints and Labor Supply: Results on Prime-age Males in Japan

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Abstract

When the labor supply is elastic with respect to the net wage rate, labor income taxation generates economic distortion and welfare loss. The substitute effect is a key determinant of the magnitude of such deadweight loss; thus, evaluating the elasticity of the labor supply has broad and significant implications for assessing the effects of changes in public policy. We estimate the labor supply function based on the CES utility function, using large microdata sets in Japan and treating the complex Japanese income tax system carefully. The results of this chapter suggest that the uncompensated elasticity of the labor supply of prime-age males is at most 0.1.

JEL: D31, D61, D63, H21, H31, J22.

Key Words: piecewise linear budget constraint, labor supply, CES utility function

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1 Introduction

When the labor supply is elastic with respect to the wage rate, labor income tax distorts the labor market and generates deadweight loss. The degree of the elasticity of the labor supply is a key factor in the magnitude of welfare loss induced by labor income taxation, which is in turn a key factor not only in the shape of optimal income tax but also in the magnitude of the marginal cost of public funds (MCPF). Thus, evaluating the elasticity of the labor supply has broad and significant implications for assessing the effects of changes in public policy.

Progressive taxation gives rise to specification and endogeneity problems in an econometric analysis of the labor supply. Since the marginal tax rate depends on the number of hours worked under a progressive taxation system, the after-tax wage rate a household faces changes as the labor supply changes. Also, virtual income varies as the after-tax wage rate varies. Rosen (1976) pioneered the analysis of a situation where the marginal wage rate depends on the labor supply. Burtless and Hausman (1978), Wales and Woodland (1979), and Hausman (1979) proposed structural estimations that explicitly consider the non-linear budget sets produced by progressive taxation, which have been used to evaluate government-managed income support programs (Moffitt 2002). In this paper, we utilize the method proposed by Zabalza (1983), assuming a CES-type utility function, which is often assumed in tax simulation studies in Japan (e.g., Honma 1991). There are few no microdata-based empirical studies that estimate the labor supply function of prime-age males (age 25 to 55) in Japan, and the parameter values used in tax simulation analysis have been rather arbitrary. In this paper, we make use of large microdata sets in Japan, treating carefully the complex Japanese income tax system. We believe this paper can provide empirical evidence for such simulation studies.

The results of this chapter suggest that the uncompensated elasticity of the labor supply of prime-age males is at most 0.1. It is widely recognized that differences in the after-tax wage rate induce modest differences in the quantity of the labour supply (Kimball and Shapiro 2003);

our results are consistent with those of previous studies, although they are based on a rather simple model that incorporates only a progressive tax system.

This paper is organized as follows. The next section briefly overviews the previous studies. A likelihood function based on a household's optimization problem is presented in Section 3. We explain data sets and a sample selection in Section 4. The results are shown in Section 5, Section 6 estimates the magnitude and distribution of the marginal costs of public funds (MCPF). And finally, the conclusions of the paper are presented in Section 7.

2 Literature

This section presents a brief survey of empirical evidence on the labor supply in order to clarify our model setting. See Pencavel (1986), Blundell and MaCurdy (1999), and Hayashi (2003) for more extensive surveys.

We focus on the labor supply of prime-age males, because our aim is to estimate the elasticities of the labor supply, which are key determinants of the magnitude of welfare loss induced by labor income taxation[(1)], and because a large part of income tax revenue is collected from prime-age males. We will not discuss decision-making or resource allocation within households. As Brett (1988) points out, intrafamily resource allocation affects welfare evaluation, but an examination of how each member determines his or her own labor supply is a subject too involved for this paper.

A considerable number of studies have been made on the intertemporal substitution of the labor supply. MaCurdy (1981, 1983), Browning et al. (1985), Reilly (1994), and Ziliak and Kniesnen (1999) investigated the elasticity of substitution based on a life-cycle hypothesis[(2)].

[(1)] The usual behavioral responses, such as a change in hours worked, are only one component of the responses to taxation change, thus a substantial body of work has been devoted to estimate the elasticity of taxable income. See Auten and Carroll (1999), Gruber and Saez (2002), Saez (2003), Miyazato (2004), and Yashio (2005).

[(2)] Camerer et al. (1997) and Farber (2003) focus on such workers who have flexibility in responding to wage fluctuations.

Studying intertemporal elasticity requires panel data, but the data we use is repeated cross-sectionally and cannot be discussed here. We examine the intratemporal elasticity based on a static model.

Our subject of research is the labor supply under progressive taxation, and we will not explicity treat other frictions in the labor market. Thus, the derived labor supply function is continuous. Recent studies have emphasized two margins of labor supply responses. First, workers are able to change their hours or the intensity of their work (intensive margin). Second, they can decide whether to enter the labor force (extensive margin). Some studies (e.g., Kimmel and Kniesner 1998) estimate two labor supply functions separately, while others explicitly assume fixed costs to enter the labor market that may cause two different margins (Hausman 1980a、Kimball and Shapiro 2003). Distinguishing between these two margins is important for welfare evaluation (Bhattarai and Whalley 2003, Eissa et al. 2004) and the design of an optimal tax system (Saez 2002). However, we will not explicitly treat the existence of the fixed costs of labor supply, because the focus of this paper is on prime-age males and because very few studies have appropriately considered the income tax structure in Japan as discussed below. In other words, we shed light on the intensive margin.

As noted above, progressive taxatino gives rise to specification and endogeneity problems in an econometric analysis of the labor supply even in a static setting. That is, the after-tax wage rate an individual faces is a function of the tax structure and the quantity of the labor supply. Rosen (1976) examined situations where the marginal wage rate depends on the labor supply. Burtless and Hausman (1978), Wales and Woodland (1979), and Hausman (1979) proposed structural estimation methods that take into account the sources of errors and the tax structure. At the beginning, they assumed a simple linear labor supply function for the individual, but their method has been applied to cases of intrafamily decision-making (Hausman and Ruud 1984) and of translog utility function (Yatchew 1985), as well as to evaluate government-managed income support programs that generate non-linear budget constraints[3].

To estimate the labor supply function, there are alternative methods that include the IV estimation (McCurdy 1981, Showalter and Thurston 1997, Kimmel and Kniesner 1998, Ziliak and Kniesner 1999, Klevmarken 2005) and the difference-in-difference method (Lee 2001, Saez 2003). In this paper, however, we adopt the method proposed by Zabalza (1983), taking advantage of the characteristics of the CES utility function. The reason for that adoption is that we can directly estimate the parameters of the CES utility function, which many tax simulation studies depend on. In addition, the likelihood function to maximize is much simpler than that of the Hausman method. This method has, however, some caveats. It is based on a static model and assumes no friction except for a progressive income tax system. In other words, workers are assumed to have a perfect, detailed knowledge of tax structure and to maximize their utility based on that knowledge without tax avoidance[4].

Before turning to the main task, a few remarks should be made concerning empirical evidence on the labor supply in Japan. Much ink has been spent on the labor supply in Japan, and the literature has two aspects different from those in the U.S. or Europe, as discussed in Bessho and Hayashi (2005) in detail.

First, there are few empirical studies that estimate the labor supply function of prime-age males, who pay a significant portion of the labor income tax revenue. Exceptionally, Okamoto (1984), Asano (1997), and Yamada et al. (1999) estimate the elasticity of the labor supply of prime-age males based on a complete demand system. Their data sets are, however, aggregate ones; that is, Okamoto (1984) uses annual time-series of national data (1963-80), Asano (1997) uses prefectural panel data (47 prefectures, 1979-90), and Yamada et al. (1999) use prefectural

[3] See Moffit (1986, 1990) for a good summary of the Hausman method. This type of structural estimation is criticized due to the possibility of implicitly imposing Slutzky conditions. See MaCurdy et al.(1990) and Blomquist (1995, 1996). Hausman (1985) argues that the method in general can be applied to cases where budget constraints are piecewise linear.

[4] People may not know their tax liabilities accurately or may even systemically misperceive them. Fiscal illusion literature investigates these topics. For example, Gemmell et al. (2004) point out a systemic bias towards the over-estimation of income tax liabilities in the U.K.

panel data in 1976, 1981, and 1986. There are almost no microdata-based empirical studies except for Naito and Yamada (2002), as far as we are aware. Shimada and Sakai (1980) make use of large microdata to estimate the labor supply function of males, but they focus on sons under 30 living with their parents.

One reason why empirical evidence on the labor supply of prime-age males is scant is that most labor economists in Japan have emphasized constraints on hours worked[5]. They often assume that workers can only either accept or reject the bundle of wage and working hours, not respond freely to the wage rate by changing the quantity of the labor supply (e.g., Higuchi and Hayami 1984). In this case, once they decide to work, their working hours are fixed and the elasticity of the labor supply along the intensive margin becomes zero. Higuchi and Hayami (1984) argue the difficulties in the female labor supply in Japan in order to explain consistently the issues of starting work and choosing labor hours from the viewpoint of utility maximization. This argument is deemed to be more suited to the case of prime-age males.

A standard labor supply model does not, however, necessarily assume that workers freely choose their working hours given their wage rates (Blundell and MaCurdy 1999). The standard model can be interpreted as a model where workers pick one pair of wage rate and labor hours from among those that several possible employers offer. We can interpret selected pairs as labor supply functions that represent workers' preferences regarding wage and working hours. Thus, the standard labor supply model is consistent with the existence of constraints on labor hours.

Second, the income tax structure has rarely been appropriately considered in relevant Japanese studies, although the wage elasticity of the labor supply or the income effect plays a crucial rule in evaluating the welfare effect of taxation. As far as we are aware, there may be a few ex-

[5] As Ogura (1996) points out, studies on working hours have been associated with a reduction in working hours in Japan. Many labor economists have put emphasis on the limitation and unreality of a leisure-goods choice model in standard microeconomics and on the institutional constraints on labor hours. Such difficulties with the evidence are also discussed in other countries. Kimball and Shapiro (2003) also indicate the difference between the observed wage in standard data series and the shadow wage within a long-term relationship between firms and workers, and constraints on workers' labor hours imposed by their employers.

ceptions (Naito and Yamada 2002, Akabayashi 2002). The before-tax wage rate has often been used as a wage rate that households face, while the virtual income that a progressive income tax system necessarily implies has not been taken into account. Because the wage elasticity of the labor supply calculated from the before-tax wage rate makes sence only when the tax structure does not change, policy evaluation based on such parameters (e.g., Homma 1991) may be problematic.

3 Model

We employ a static framework where an individual maximizes the CES utility function controlling his labor supply. The CES utility function is

$$u(x_i, h_i) = \left(x_i^{-\rho} + \alpha(T - h_i)^{-\rho}\right)^{-\frac{1}{\rho}}, \tag{3.1}$$

where x_i is composite good consumption, h_i is labor supply, and $\alpha, \rho > -1$ are parameters.(6) The weight parameter α is assumed to be determined by personal characteristics and a random component. We define

$$\alpha_i = \exp(Z_i\gamma - \varepsilon_i), \tag{3.2}$$

where a vector Z_i represents the personal characteristics, γ is a corresponding coefficient vector, and ε_i is a partially additive separable random component. Note that the parameter α must be positive.

Since Japanese income tax rates are graduated, the marginal tax rate the individual faces differs according to the quantity of the labor supply. Generally speaking, when a price changes discontinuously according to the quantities of the good, the budget line kinks at that point. Such

(6) Many studies in Japan employ such functional form as $u(x, h) = ((1-\beta)x^{-\rho} + \beta(T-h)^{-\rho})^{-1/\rho}$, where $\beta = \alpha/(1+\alpha)$.

cases include progressive taxation, public transfers (unemployment benefits or food stamps) or home purchases. The budget set may or may not be convex, but it is convex in the case of a simple progressive income tax system. We here set the price of a composite good to unity, and the budget line of the k-th segment becomes

$$x_{ki} = w_{ki}h_{ki} + y_{ki}, \tag{3.3}$$

where w_{ki} is the after-tax marginal wage rate and y_{ki} is the after-tax virtual income. Some calculations give us the labor supply function:

$$h_{ki} = \frac{T(w_{ki}/\alpha_i)^{\frac{1}{1+\rho}} - y_{ki}}{w_{ki} + (w_{ki}/\alpha_i)^{\frac{1}{1+\rho}}}. \tag{3.4}$$

Taking into account the assumption about the parameter α_i (3.2), we can rewrite the labor supply function h_{ki} with the after-tax wage rate w_{ki}, non-labor income y_{ki}, personal characteristics $\mathbf{Z}_i$ and the random component ε_i as

$$h_{ki} = \frac{T(w_{ki}/\exp(Z_i\gamma - \varepsilon_i))^{\frac{1}{1+\rho}} - y_{ki}}{w_{ki} + (w_{ki}/\exp(Z_i\gamma - \varepsilon_i))^{\frac{1}{1+\rho}}}. \tag{3.5}$$

The after-tax wage rate w_{ki} is a product of the before-tax wage rate W_i and one minus the marginal tax rate. This labor supply function can be transformed to(7)

$$(w/\alpha)^{\frac{1}{1+\rho}} = \frac{wh + y}{T - h} = \frac{x}{l}, \tag{3.6}$$

which holds in equilibrium given the after-tax wage rate and virtual income. Now we are assumed to observe the labor supply with the interval, $[h_L, h_H]$. Figure 1 represents the budget set. We denote the unobserved optimal labor supply as h^*, the optimal leisure consumption as l^* and the optimal composite good consumption as x^*, with the corresponding after-tax wage

(7) We assume here the convexity of the budget set, and drop the subscript ki for simplicity hereafter.

rate, w^*, and virtual income, y^*. Then in equilibrium

$$(w^*/\alpha)^{\frac{1}{1+\rho}} = \frac{w^*h^* + y^*}{T - h^*} = \frac{x^*}{l^*}$$

holds. Figure 1 implies

$$\frac{x_L}{l_L} \leq \frac{x^*}{l^*} \leq \frac{x_H}{l_H}, \tag{3.7}$$

where subscripts H and L are the upper and the lower end of the interval, respectively. Under the assumption of a convex budget set and $1 + \rho > 0$, we can obtain from the right-hand side of the equation that

$$\frac{x_H}{l_H} \geq \frac{x^*}{l^*} = (w^*/\alpha)^{\frac{1}{1+\rho}} \geq (w_H/\alpha)^{\frac{1}{1+\rho}},$$

thus,

$$\frac{w_H h_H + y_H}{T - h_H} \geq (w_H/\alpha)^{\frac{1}{1+\rho}}. \tag{3.8}$$

Similarly, from the left-hand side of the equation (3.7) we get

$$\frac{x_L}{l_L} \leq \frac{x^*}{l^*} = (w^*/\alpha)^{\frac{1}{1+\rho}} \leq (w_L/\alpha)^{\frac{1}{1+\rho}}$$

and

$$\frac{w_L h_L + y_L}{T - h_L} \leq (w_L/\alpha)^{\frac{1}{1+\rho}}. \tag{3.9}$$

Therefore, the probability that we observe the labor supply between $[h_L, h_H]$ becomes

$$\Pr\left(\frac{w_H h_H + y_H}{T - h_H} \geq (w_H/\alpha)^{\frac{1}{1+\rho}} \text{ and } (w_L/\alpha)^{\frac{1}{1+\rho}} \geq \frac{w_L h_L + y_L}{T - h_L}\right).$$

Thus, the contribution to the likelihood of the individual is

$$L = \Pr\left(\left[\frac{w_H h_H + y_H}{T - h_H}\right]^{1+\rho} \alpha \geq w_H \text{ and } w_L \geq \left[\frac{w_L h_L + y_L}{T - h_L}\right]^{1+\rho} \alpha\right).$$

We are now assuming that α can be represented with the observed personal characteristics and the unobserved random component as in (3.2); then

$$\begin{aligned} L &= \Pr\left(\exp(Z\gamma - \varepsilon) \geq w_H \left[\frac{w_H h_H + y_H}{T - h_H}\right]^{-1-\rho} \text{ and } w_L \left[\frac{w_L h_L + y_L}{T - h_L}\right]^{-1-\rho} \geq \exp(Z\gamma - \varepsilon)\right) \\ &= \Pr\left(\varepsilon \leq Z\gamma - \ln w_H \left[\frac{w_H h_H + y_H}{T - h_H}\right]^{-1-\rho} \text{ and } Z\gamma - \ln w_L \left[\frac{w_L h_L + y_L}{T - h_L}\right]^{-1-\rho} \leq \varepsilon\right) \\ &= \Pr\left(\varepsilon \leq Z\gamma - \ln w_H + (1+\rho) \ln \left[\frac{w_H h_H + y_H}{T - h_H}\right] \text{ and } Z\gamma - \ln w_L + (1+\rho) \ln \left[\frac{w_L h_L + y_L}{T - h_L}\right] \leq \varepsilon\right). \end{aligned}$$

When we add the assumption that $\varepsilon \sim N(0, \sigma^2)$, the contribution becomes

$$L = \Phi\left(\frac{Z\gamma}{\sigma} - \frac{1}{\sigma} \ln w_H + \frac{1+\rho}{\sigma} \ln \left[\frac{w_H h_H + y_H}{T - h_H}\right]\right) - \Phi\left(\frac{Z\gamma}{\sigma} - \frac{1}{\sigma} \ln w_L + \frac{1+\rho}{\sigma} \ln \left[\frac{w_L h_L + y_L}{T - h_L}\right]\right)$$

where $\Phi(\cdot)$ is the distribution function of the normal distribution. Given the independency among individuals, the likelihood function is the sum of these contributions.

4 Data

4.1 Data and Sample Selection

As mentioned, the data source we utilize for our sample is *Syugyo Kozo Kihon Chosa* [Employment Status Survey] conducted in 1997 and 2002. We focus on the labor supply of prime-age males (25-55) who are classified as the head of the household with a non-working spouse, and we exclude the following observations from the sample: (a) self-employed workers, (b) board members of private companies and non-profit organizations, (c) family workers for SMEs, (d) those unemployed due to illness, (e) those who had changed their residence or job within the previous year, and (f) those who had children within the previous year. We also leave out those with non-labor income because the survey does not provide the point value for that variable (therefore the sample consists of only those with labor income). These omissions reduce the sample size down to 81,410 for 1997 and 68,932 for 2002.

The dependent variable (hours worked) is provided as interval data in the survey. The hours are measured as an annual flow. On the other hand, our independent variables are standard and consist of the after-tax (net) wage, virtual income, age, age squared, the number of children under 15 years of age, and the number of dependents other than said children. The net wage is calculated as a product of gross wages and one minus the marginal tax rate. Since the data for hours worked are provided as intervals, we could not obtain gross wages as a ratio of annual income to annual hours worked. We instead follow Shimada and Sakai (1980) to construct gross wage data from *Chingin Kozo Kihon Tokei Chosa* [Basic Survey on Wage Structure] and match them with the observations used in our sample. Specifically, we construct a tabulation of gross wages sorted by (a) sex, (b) educational background, (c) age, and (d) place of residence (47 prefectures) and assign them with those observations that share the same combination of the four items(8). The marginal tax rate and virtual income are calculated using a close examination of the Japanese tax codes in 2002, as mentioned below. Note that the virtual income excludes non-labor income since our sample consists of those with only labor income. As such, variations in virtual income come from those in gross wages as well as household characteristics that affect exemptions and credits. Table 1 shows the summary statistics of said variables.

(8)We also construct gross wage data as a ratio of annual income to annual hours worked, which are assumed as a midpoint of the interval.

4.2 Budget Set

We use the microdata collected in 1997 and 2002, and we calculate the amount of income tax for each individual is calculated as follows[9]. The income tax on individuals includes "income tax", which is a national tax, and "inhabitant tax", which is a local tax[10]. The process used to compute the tax amount is virtually the same for both the income tax and the inhabitant tax. First, we derive "employment income" as the salaries the individual receives minus the "employment income deduction". Second, "taxable income" is defined as the "employment income" minus certain kinds of deductions and allowances. Finally, we apply the tax rates to taxable income and subtract certain tax credits, if any, to obtain the tax amounts. In FY2002, there is the proportional tax credit with an upper bound for income tax and inhabitant tax.

The available deductions, allowances, or tax credits differ as individual characteristics differ. Since we cannot take into account some of those differences because of data limitation, we must *estimate* the budget sets. What we employ are basic allowance, allowance for spouses, special allowance for spouses, allowance for dependents, allowance for specific dependents[11], employment income deduction, and deduction for social insurance premiums[12]. We take the social insurance premium as a tax, and we calculate the marginal income tax rate considering not only the tax rate and the social insurance premium rate but also the employment income deduction and the deduction for social insurance premium, which vary according to before-tax labor income.

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[9] We here outline the income tax system in Japan, but do not treat cases where individuals have income sources other than labor earnings, because we focus on those who have only labor income (salary).

[10] The amount of the inhabitants tax is calculated based on the income in the previous year in practice. Since our data sets is not panel data, however, the inhabitant tax is assumed to be computed using the current income.

[11] A "specific dependent" is a dependent who is aged between 16 and 23 who does not work.

[12] The deduction amount for social insurance premiums is the full amount of social insurance premiums. We assume public pension insurance, public health insurance, and public unemployment insurance as social insurance. The premiums of social insurance differ as places of work differs. However, the data does not contain such information needed to calculate the social insurance premium. We assume that the social insurance premium is 14.125% if the firm where the individual works employs less than 1000 people, 14.806% if there are more than 1000 people, and 12.9395% if the individual is a public servant. We ignore the upper limit of the social insurance premium.

Because we consider the social insurance premium as a national tax, the determinants of the virtual marginal tax rate consist of the tax rate of income tax and inhabitant tax, the rate of the employment income deduction and the rate of social insurance premium. When the deductions and allowances for the income tax are equal to or larger than those for the inhabitants tax, then the possible pairs of marginal tax rates of the income tax and the inhabitants tax are 9 in 1997 and 10 in 2002. Once we compute the kink points in terms of before-tax income, the corresponding kink points in terms of hours worked can be obtained by dividing them by the before-tax wage rate. Now we have the rates of the income tax, the inhabitant tax, the social insurance premium, the social insurance premium deduction, and the employment income deduction for each segment; thus, the virtual marginal tax rate and virtual income that workers face are easily calculated.

4.3 Evaluation of Elasticities

Because the estimated coefficients depend on the units of composite goods or labor income, we evaluate the estimated labor supply function using elasticity as follows. First, we derive the indirect utility functions by substituting into the direct functions the demand function for leisure and the composite good, which can be obtained using the labor supply function (3.4) and the budget equation (cf. Hausman 1980b, Stern 1986):

$$v(w_i, y_i) = \frac{(w_i T + y_i)[(w_i/\alpha_i)^{-\frac{\rho}{1+\rho}} + \alpha]^{-\frac{1}{\rho}}}{w_i + (w_i/\alpha)^{\frac{1}{1+\rho}}}.$$

Then, once the characteristics of the individual, quantity of the labor supply, and the set of (w_i, y_i) that he or she faces are identified, the uncompensated elasticity of the labor supply, $\hat{\eta}_i$, the income effect, $\hat{\phi}_i$, and the compensated elasticity, $\hat{\eta}_i^c$, are given by

$$\hat{\eta}_i = \frac{y_i}{h_i}\left(w_i + (w_i/\hat{\alpha}_i)^{\frac{1}{1+\rho}}\right)^{-1}, \tag{4.1}$$

$$\hat{\phi}_i = -w\left(w_i + (w_i/\hat{\alpha}_i)^{\frac{1}{1+\rho}}\right)^{-1}, \tag{4.2}$$

$$\hat{\eta}_i^c = \eta_i - \hat{\phi}_i. \tag{4.3}$$

These formulae give us the elasticities, but two problems arise in practice. One is associated with the fact that our data for the hours worked are coded intervals, and the other is that we cannot define the elasticities at kink points.

To deal with the former problem we evaluate the elasticities at the fitted value based on the estimated labor supply function. Since we estimate the parameters that appear in the direct utility function, we can get the optimal quantity of the labor supply given the budget sets derived as above, assuming that the preference heterogeneity equals zero. That is, we calculate the labor supply and the utility level of each segment and kink point using the labor supply function and the direct/indirect utility function, and then we compare the utility levels to pin down the optimal point. Note that the assumption about preference heterogeneity makes the variance of estimated working hours smaller than that of actual hours.

Now we fight the latter problem. As can be easily seen, the optimal labor supply is often given at kink points if the budget line is piecewise linear(13). Common marginal wage rates cannot be defined at kink points, nor can elasticities. Since elasticities can be calculated once the marginal wage rate, quantities of the labor supply, and consumption goods are given, we employ quantities of the labor supply and consumption goods at kink points and the marginal wage rate of the "next" segment. That is, the wage rate used is that of the segment where the labor supply increases a little bit from the chosen kink point.

(13) As noted above, our data for the hours worked are coded intervals. This makes it impossible to verify actual labor supply is near kink points.

5 Estimation Results

Tables 2 and 3 show the summary statistics. There seems to be no significant change in the before-tax wage rate or other family characteristics, and hours worked are slightly longer in 2002 than in 1997.

Table 4 lists the estimation results. Columns 1 and 4 show the results where individual characteristics are not taken into account. The parameter ρ, which represents the elasticity of substitution of the CES utility function, is estimated in the range between minus one to zero. Note that if ρ equals minus one or zero, the CES utility function becomes the linear utility function or Cobb-Douglas, respectively. Turning to other variables, the number of children under 14 years of age has a negative effect on the leisure weight, while the number of "specific" dependents has a positive effect. The coefficients for dummies of education are estimated to be negative, which means that high school graduates have the highest leisure weight.

The elasticities for each individual based on the estimation results are shown in Table 5. Average compensated elasticities range around 0.005, and average income effects from -0.059 to -0.054, while average Marshallian elasticities are about 0.06. This means that a typical worker who earns 3,000 yen an hour and who works 2,500 hours a year increases his working hours by only 1.5 hours per year in response to a 1% increase in his wage rate. Such low elasticities are consistent with the literature. The standard deviation of the elasticities is rather small, partly because we evaluate the elasticities at the points of fitted values. The results do not vary significantly when based on estimation results where the educational variables are added as explanatory variables.

As noted above, we match gross wage data from *Chingin Kozo Kihon Tokei Chosa* [Basic Survey on Wage Structure] with the observations used in our sample. We have, however, an alternative way to calculate them making use of midpoint data of gross income and working hours in our sample. Tables 6 and 7 shows the sample statistics in this case, while the estimation results are presented in Table 8.

Columns 1 and 4 show those cases where we exclude all explanatory variables except for constants. In this case, the parameter ρ, the elasticity of substitution, is estimated in the range between zero to one, which means the CES utility functions lie between Cobb-Douglas and the Leontief-type utility function. The estimated α is larger than in previous cases. Other columns suggest the different effects of individual characteristics on the leisure weight: the sign of the coefficients of age is the same, but the magnitude differs. The signs of the coefficients of specific dependent children or dummies for education are reversed. These results show that the estimation results depend on how the gross wage rates are calculated.

Table 9 shows the estimated elasticities of the labor supply based on the results shown in Table 8, evaluated at the midpoint of the interval in our sample. Since the evaluation point disperses, the standard deviation of the labor supply elasticities are calculated as far larger than those in Table 5. On average, the labor supply elasticities are also estimated as larger, but still rather small. These results are consistent with Zabalza et al. (1980), which assumes the CES utility function. The differences between Tables 5 and 9, which may be due to division bias, seem like the results in Ziliak and Kniesner (1999).

6 Individual MCPF

With the estimates given above, we calculate the MCPF (marginal cost of public funds) for the individual, that will be generated if the government raises one additional unit of tax revenue from that person. Following Bessho et al. (2003), the MCPF for individual i can be defined as:

$$\mathrm{MCPF}_i \equiv 1 + \left(\eta_i^c \frac{dm_i}{da_i} + \phi_i\right) \cdot \left(\frac{1-m}{m} - \eta_i^c \frac{a_i}{m_i}\frac{dm_i}{da_i} - \phi_i\right)^{-1}, \tag{6.1}$$

where a_i is the average tax rate and m_i is the marginal tax rate. Note that we calculate the MCPFs individually so that each household in our sample is associated with its own MCPF. At least conceptually, it is possible to obtain the social marginal cost of public funds (SMCF), which is the additional welfare cost from one additional unit of tax revenue, by "aggregating" all individual MCPFs with the distribution weights that are derived from some specific social welfare functions. Because there seems to be no consensus about the specification of the social welfare function and because a fuller study of the distribution weight lies outside the scope of this paper, we focus here on the MCPF for each individual.

The calculation of (6.1) requires additional values for a_i and $dm_i/d\,a_i$. Bessho et al. (2003) consider the case where the additional tax revenue is raised through an increase in the marginal tax rate. In this exercise, we simply assume the average tax rate elasticity of the marginal tax rate as a unity for convenience (i.e., $(a/m)dm_i/da_i = 1$)[14].

The distribution of the individual MCPFs is given in Figure 2, which shows that most of the values cluster between 1.00 and 1.02 based on the parameters in Table 5. The individual MCPFs range from 1 to 1.19 with average 1.01 and a standard error of 0.012 in 1997, while in 2002 the average is 1.007 and the standard error is 0.009. These small estimates of the MCPFs[15] are due to our small estimates of the elasticities for the prime-age males. This conforms to our previous study (Bessho et al. 2003), which shows with some sensitivity analysis that the MCPF would be 1.1 *at most* under the assumption of the representative consumer.

7 Concluding Remarks

When the labor supply is elastic with respect to the net wage rate, labor income taxation generates economic distortion and welfare loss. The substitute effect is a key determinant of the magnitude of such deadweight loss; thus, evaluating the elasticity of the labor supply has

(14) The results are almost same for these two assumption.

(15) Even if we use the parameters in Table 9, the average MCPFs are estimated as 1.04 in 1997 and 1.02 in 2002.

broad and significant implications for assessing the effects of changes in public policy. There are, however, few microdata-based empirical studies that estimate the labor supply function of prime-age males in Japan while appropriately considering the income tax structure. This paper explicitly takes into account the piecewise linearity induced by the graduated income tax system, making use of microdata from two waves of *Syugyo Kozo Kihon Chosa* [Employment Status Survey] conducted in 1997 and 2002. Assuming the CES utility function, we estimate the elasticities of the labor supply with respect to the net wage rate and virtual income. The results show that the Marshallian labor supply elasticity is at most 0.1, which is consistent with the literature. Our estimation is based on a simple theoretical model, excluding the distinction between intensive and extensive margins or intertemporal substitution. These topics suggest the direction of our future research.

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Figure 1. Piecewise-linear budget constraint

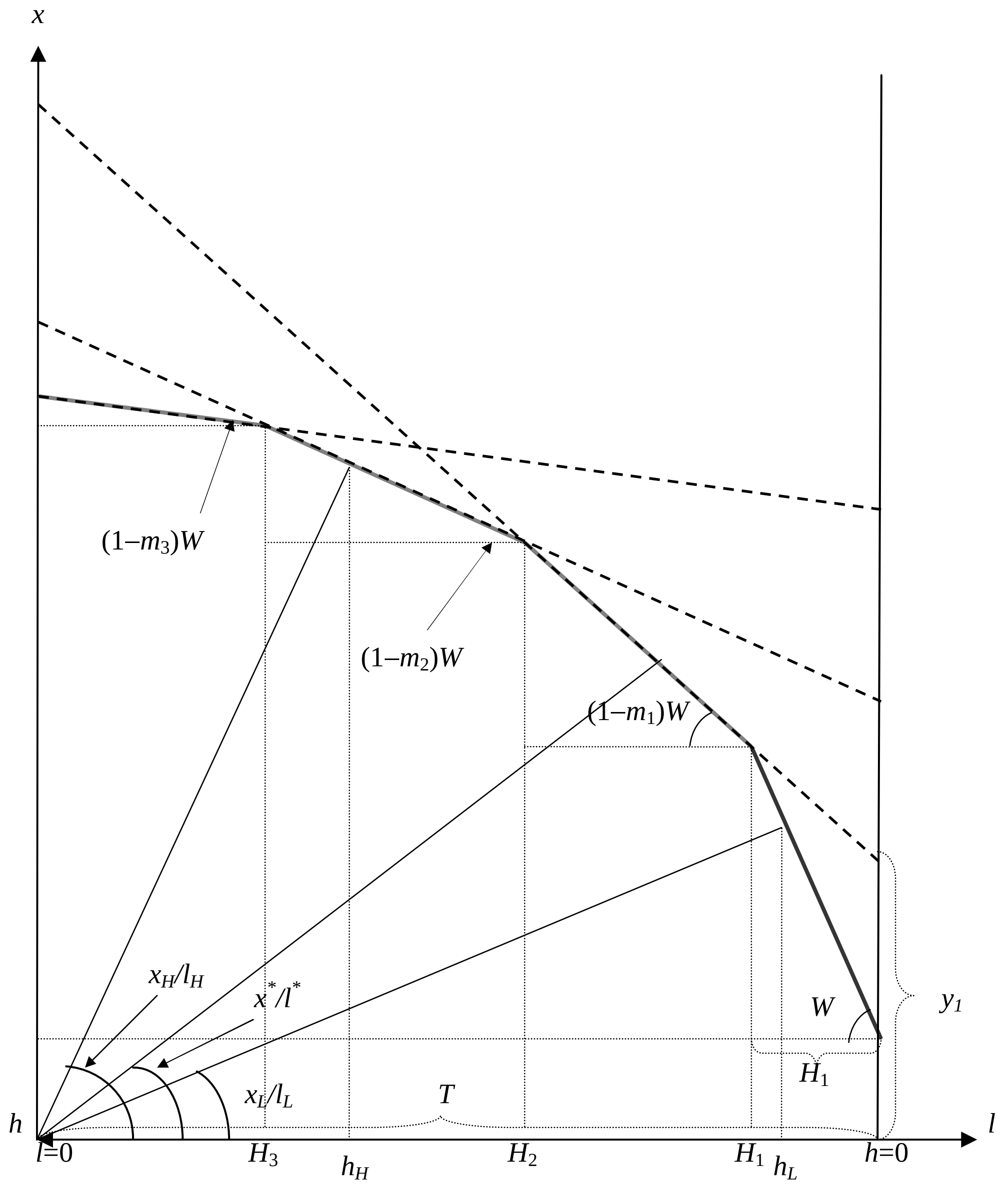

Table 1. Japanese personal income tax system

	1997		2002	
	Income tax	Inhabitants tax	Income tax	Inhabitants tax
Basic allowance	380	330	380	330
Allowance for spouses	380	330	380	330
Special allowance for spouses	380	330	380	330
Allowance for dependents	380	330	380	330
Allowance for specific dependents	530	410	630	450
Employment income deduction	Not over 1,800, 40% Not over 3,600, 30% Not over 6,600, 20% Not over 10,000, 10% Over 10,000, 5%	Not over 1,800, 40% Not over 3,600, 30% Not over 6,600, 20% Not over 10,000, 10% Over 10,000, 5%	Not over 1,800, 40% Not over 3,600, 30% Not over 6,600, 20% Not over 10,000, 10% Over 10,000, 5%	Not over 1,800, 40% Not over 3,600, 30% Not over 6,600, 20% Not over 10,000, 10% Over 10,000, 5%
Lower limit	650	650	650	650
Tax rate	Not over 3,300, 10% Over 3,300, 20% Over 9,000, 30% Over 18,000, 40% Over 30,000, 50%	Not over 2,000, 5% Over 2,000, 10% Over 7,000, 15%	Not over 3,300, 10% Over 3,300, 20% Over 9,000, 30% Over 18,000, 37%	Not over 2,000, 5% Over 2,000, 10% Over 7,000, 13%
Proportional tax credit			20% Upper limit: 250	15% Upper limit: 40

Table 2. Sample statistics, 1997

	Average	Std. err.	max	min
Before-tax wage rate	0.281	0.087	0.087	0.613
Hours worked (lower end)	1387.3	376.2	0	2142.9
Hours worked (upper end)	2460.8	1256.9	107.1	5840
Age	42.470	8.029	25	55
# of kids younger than 15	0.879	1.005	0	7
# of Specific dependent children	0.275	0.554	0	4
Junior high school	0.139	0.346	0	1
High school	0.489	0.500	0	1
2-year college	0.062	0.240	0	1
4-year college, graduate school	0.310	0.463	0	1

(Note) Sample size is 73697.

Table 3. Sample statistics, 2002

	Average	Std. err.	max	min
Before-tax wage rate	0.266	0.090	0.072	0.591
Hours worked (lower end)	1450.9	401.8	0	2142.9
Hours worked (upper end)	2659.7	1427.4	107.1	5840
Age	42.794	8.191	25	55
# of kids younger than 15	0.949	1.002	0	6
# of Specific dependent children	0.270	0.557	0	4
Junior high school	0.105	0.307	0	1
High school	0.473	0.499	0	1
2-year college	0.080	0.271	0	1
4-year college, graduate school	0.342	0.474	0	1

(Note) Sample size is 63703.

Table 4. Estimation results based on CES utility function

	1997	1997	1997	2002	2002	2002
Age		-0.0044	-0.0024		-0.0088	-0.0079
		(0.002)	(0.002)		(0.002)	(0.002)
Age^2		0.0001	0.0001		0.0002	0.0002
		(0.000)	(0.000)		(0.000)	(0.000)
# of kids younger than 15		-0.0048	-0.0044		-0.0055	-0.0051
		(0.002)	(0.002)		(0.002)	(0.002)
# of Specific dependent children		0.0115	0.0105		0.0073	0.0060
		(0.003)	(0.002)		(0.003)	(0.003)
Junior high school			-0.0738			-0.0778
			(0.004)			(0.005)
2-year college			-0.0066			-0.0012
			(0.006)			(0.006)
4-year college, graduate school			-0.0013			0.0017
			(0.004)			(0.004)
constant	1.4246	1.1370	0.9265	1.1570	1.0549	0.9284
	(0.017)	(0.048)	(0.056)	(0.015)	(0.052)	(0.055)
ρ	-0.0199	-0.0668	-0.1177	-0.0588	-0.1101	-0.1423
	(0.006)	(0.006)	(0.009)	(0.005)	(0.005)	(0.007)
σ	0.3484	1.1370	0.3031	0.3633	0.3420	0.3302
	(0.002)	(0.048)	(0.003)	(0.002)	(0.002)	(0.003)
# of observation	73697	73697	73697	63703	63703	63703
Log Likelihood	-74238.2	-73720.0	-73572.1	-69727.9	-69184.1	-69074.8

(Note) Figures in parentheses show standard error.

Table 5. Elasticities, income effects

	Average	Std. err.	max	min
1997, without educational variables				
η	0.005	0.005	0.000	0.048
ϕ	-0.059	0.032	-0.251	-0.005
η_c	0.064	0.037	0.006	0.297
α	3.218	0.155	3.610	2.956
1997, with educational variables				
η	0.005	0.005	0.000	0.048
ϕ	-0.059	0.032	-0.253	-0.005
η_c	0.064	0.037	0.006	0.297
α	2.767	0.160	3.177	2.335
2002, without educational variables				
η	0.004	0.005	0.040	0.000
ϕ	-0.057	0.035	-0.005	-0.259
η_c	0.061	0.039	0.298	0.005
α	2.734	0.144	3.058	2.499
2002, with educational variables				
η	0.004	0.005	0.040	0.000
ϕ	-0.057	0.035	-0.005	-0.259
η_c	0.061	0.039	0.299	0.005
α	2.485	0.148	2.824	2.090

Table 6. Sample statistics, 1997

	Average	Std. err.	max	min
Before-tax wage rate	0.281	0.087	0.087	0.613
Labor income (10 ths yen)	0.377	0.257	0.006	23.333
Hours worked (midpoint)	621.26	272.30	25	2000
Hours worked (lower end)	1924.07	802.13	53.57	3991.43
Hours worked (upper end)	1387.35	376.13	0	2142.86
Age	2460.78	1256.84	107.14	5840
# of kids younger than 15	42.467	8.031	25	55
# of Specific dependent children	0.879	1.005	0	7
Junior high school	0.275	0.554	0	4
High school	0.139	0.346	0	1
2-year college	0.489	0.500	0	1
4-year college, graduate school	0.062	0.240	0	1

(Note) Before-tax rate is calculated by dividing labor income by hours worked. Sample size is 73,592.

Table 7. Sample statistics, 2002

	Average	Std. err.	max	min
Before-tax wage rate	0.347	0.256	0.006	12.133
Labor income (10 ths yen)	600.82	287.68	25	2000
Hours worked (midpoint)	2080.42	912.86	53.57	3991.43
Hours worked (lower end)	1461.98	405.44	0	2142.86
Hours worked (upper end)	2698.86	1450.20	107.14	5840
Age	43.069	8.169	25	55
# of kids younger than 15	0.939	1.005	0	6
# of Specific dependent children	0.276	0.563	0	4
Junior high school	0.105	0.306	0	1
High school	0.471	0.499	0	1
2-year college	0.080	0.272	0	1
4-year college, graduate school	0.344	0.475	0	1

(Note) Before-tax rate is calculated by dividing labor income by hours worked. Sample size is 68,932。

Table 8. Estimation results based on CES utility function

	1997	1997	1997	2002	2002	2002
Age		-0.0621	-0.0524		-0.0929	-0.0767
		(0.002)	(0.003)		(0.003)	(0.003)
Age^2		0.0007	0.0005		0.0010	0.0007
		(0.000)	(0.000)		(0.000)	(0.000)
# of kids younger than 15		-0.0339	-0.0351		-0.0371	-0.0400
		(0.002)	(0.002)		(0.003)	(0.003)
# of Specific dependent children		-0.0604	-0.0625		5.6916	-0.0580
		(0.003)	(0.003)		(0.072)	(0.004)
Junior high school			0.1923			0.2335
			(0.006)			(0.008)
2-year college			-0.0947			-0.0800
			(0.008)			(0.009)
4-year college, graduate school			-0.2273			-0.2890
			(0.004)			(0.005)
constant	3.0468	4.6824	5.0431	3.3076	5.6926	5.9794
	(0.015)	(0.055)	(0.058)	(0.018)	(0.000)	(0.076)
ρ	0.6105	0.6797	0.8150	0.8385	0.8885	0.9677
	(0.005)	(0.006)	(0.007)	(0.004)	(0.004)	(0.005)
σ	0.3793	0.3861	0.3959	0.4522	0.4620	0.4743
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
# of observation	81410	81101	81101	68932	68932	68932
Log Likelihood	-59603.2	-58423.8	-55827.4	-55539.7	-54260.6	-51803.3

(Note) Before-tax rate is calculated by dividing labor income by hours worked. Figures in parentheses show standard error.

Table 9. Elasticities, income effects

	Average	Std. err.	max	min
1997, without educational variables				
η	0.017	0.163	0.000	43.777
ϕ	-0.114	0.883	-218.082	0.000
η_c	0.131	1.042	0.000	261.860
α	25.659	2.320	34.672	18.396
1997, with educational variables				
η	0.017	0.163	0.000	43.625
ϕ	-0.114	0.881	-217.322	0.000
η_c	0.131	1.040	0.000	260.947
α	38.168	6.680	22.497	68.608
2002, without educational variables				
η	0.014	0.056	6.083	0.000
ϕ	-0.111	0.484	0.000	-87.224
η_c	0.124	0.530	93.307	0.000
α	35.183	4.322	54.160	25.404
2002, with educational variables				
η	0.013	0.056	6.030	0.000
ϕ	-0.109	0.480	0.000	-86.468
η_c	0.122	0.525	92.498	0.000
α	54.316	11.944	116.856	30.734

(Note) Before-tax rate is calculated by dividing labor income by hours worked. Elasticities and income effects are evaluated at midpoint of observed interval.

Figure 2. The estimated distribution of individual MCPFs.