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The Social Cost of Public Funds: The Case of Japanese Progressive Income Taxation

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The Social Cost of Public Funds: The Case of Japanese Progressive Income Taxation*

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Abstract

This paper operationalizes Dahlby (1998)'s theoretical analysis on the social marginal cost of public funds (SMCF) with microdata on Japanese prime-age males. Our exercise, however, is more than an application. First, we derive the formula for the SMCF that differentiates every individual. Second, we estimate the labour supply function of Japanese prime-age males which no previous studies have appropriately considered. Third, taking advantage of our formula, we also calculate the SMCF for sub-groups among our samples. We provide a region-specific SMCF and, following Dahlby and Wilson (1994), discuss the desirable direction of regional transfers. We also present an "individual" MCF.

1 Introduction

The marginal cost of public funds (MCPF) is an important tool for applied cost-benefit analysis as well as policy reforms. First, since the MCPF measures an increase in the social cost of taxation caused by a unit increase in public sector revenue, we could use it as a multiplier to

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estimate the *effective* cost of a public project. Second, we could see desirable directions for tax changes by estimating the MCPFs over available tax instruments, since an optimal tax mix necessarily equates all the MCPFs over tax bases. Most of the MCPF literature is predicated on a single-person or many-identical-persons economy framework. For example, Bessho *et al.* (2003) estimate the MCPF year by year assuming representative agent. Such assumption is, however, inconsistent with the real working of our economy: consumers are heterogeneous and the system of progressive taxation is in place. Since progressive taxation intends to account for equity as well as efficiency, it necessitates an explicit distributional consideration when calculating the "social" cost of taxation. Dahlby (1998) is among the first who integrate the distributional aspect into the calculation of the MCPF in order to provide a meaningful indicator for policy evaluation, which is called "the social marginal cost of public funds" (SMCF). His contribution is also found in the fact that, when providing the formula for calculating the SMCF, he explicitly takes into account a piecewise linear budget constraint that the progressive income tax schedule entails.

In this paper, we apply Dahlby (1998)'s theoretical analysis to microdata on Japanese households. We believe, however, that our exercise is more than an application. First, we derive the formula for the SMCF that differentiates every individual. Dahlby (1998) assumed identical individuals within a given bracket. The actual data, of course, show that individuals are heterogeneous even within a single bracket, and that has to be accounted for in the actual calculation of the SMCF. Second, we used the labour supply function of Japanese households estimated in Bessho and Hayashi (2005). The SMCF requires a complete characterization of individual preferences since it contains distributional weights defined with a Bergson-Samuelson-type social welfare function. In fact, we do not have appropriate preference parameters for the leisure-labor choice for the Japanese consumers, which is in sharp contrast to the rich empirical literature that exists for their North American and European counterparts. Third, while we calculate the three types of progressivity-preserving SMCFs proposed in Dahlby (1998), we also provide region-specific SMCFs, with which, following Dahlby and Wilson (1994), the desirable direction of regional transfers could be examined. Lastly, we disaggregate SMCF to obtain MCPFs defined on individual basis. Specifically, we show how such individual MCPFs are distributed over the sample we used for the estimation. We also look at how such the distribution of individual MCPFd varies over the regions and income classes.

The paper is constructed as follows. Section 2 sets up the model and extends the existing SMCF formula for our purposes. Section 3 specifies social welfare functions as well as individual preferences and discusses relevant preference parameters as well as the patterns of tax changes. Section 4 calculates the SMCFs, as well as distributions of individual MCPFs. The paper's conclusions are offered in Section 5.

2 The model and formula

2.1 The setup

An individual i consumes a numeráire x_i and leisure l_i to obtain utility $u_i = u_i(x_i, l_i)$.[1] His net wage rate is given as $w_i = (1 - m_i)W_i$ where W_i is the pre-tax wage rate and m_i is the marginal tax rate that individual i faces. His time endowment is expressed as T so that his hours worked are given as $h_i = T - l_i$. He faces a piecewise linear budget constraint due to the progressivity of the income tax system. When choices are made off the kinks of the piecewise linear budget constraint, the constraint can be represented as a linear budget constraint with slope w_i and virtual income y_i. We therefore obtain individual i's indirect utility function as

$$v_i(w_i, y_i) \equiv \max_{x_i, h_i} \{u(x_i, T - h_i) \,|x_i = w_i h_i + y_i, h_i \leq T\}. \tag{1}$$

[1] We follow Dahlby (1998) to set aside the revenue effect of public services in calculating MCPF, and leave it to the benefit side of project evaluation. We therefore set the level of public service fixed in our analysis so that it does not appear in our expression of utility function.

The social welfare in the society is represented by a Bergson-Samuelson-type social welfare function:

$$S = S(\mathbf{v}) \tag{2}$$

where $\mathbf{v} = \{v_i\}$ is a vector of utilities of all of the individuals in this society. Since the social marginal cost of public funds (SMCF) is defined as a reduction in the social welfare caused by a unit increase in tax revenue, it is given as

$$\mathrm{SMCF} \equiv \frac{dS/(\partial S/\partial y_k)}{dR} \tag{3}$$

where R represents tax revenue. Note that the change in the social welfare is normalized with the marginal utility of the income of consumer k

$$\frac{\partial S}{\partial y_k} \equiv \frac{\partial S}{\partial v_k}\frac{\partial v_k}{\partial y_k} \tag{4}$$

so that the SMCF is expressed in the unit of the numeráire.

Following Dahlby (1998), we obtain a change in tax revenue from individual i (R_i) as

$$dR_i = W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c \frac{dm_i}{d\bar{a}_i} + \phi_i\right)\right] d\bar{a}_i \tag{5}$$

where $d\bar{a}_i$ is a change in the average tax rate that holds pre-tax labor income $W_i h_i$ constant, $\eta_i^c \equiv (\partial h_i/\partial w_i|_u)(w_i/h_i)$ is the compensated wage elasticity of the labor and $\phi_i \equiv w_i \partial h_i/\partial y_i$ is what we call income effect. Note that the uncompensated wage elasticity of the labor is given as $\eta_i \equiv (\partial h_i/\partial w_i)(w_i/h_i) = \eta_i^c + \phi_i$. Therefore, a change in the total revenue R is given as

$$\begin{aligned} dR &\equiv \sum_i dR_i \\ &= \sum_i W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c \frac{dm_i}{d\bar{a}_i} + \phi_i\right)\right] d\bar{a}_i. \end{aligned} \tag{6}$$

A change in the social welfare is expressed as

$$dS = \sum_i \frac{\partial S}{\partial v_i} dv_i \tag{7}$$

where Roy's identity gives changes in the individual utilities as

$$dv_i = -\frac{\partial v_i}{\partial y_i} W_i h_i d\bar{a}_i. \tag{8}$$

We then obtain a change in the social welfare normalized with individual k's marginal utility of income as

$$\frac{dS}{\partial S/\partial y_k} = -\sum_i \omega_i W_i h_i d\bar{a}_i \tag{9}$$

where ω_i is the distribution weight attached to individual i defined as

$$\omega_i \equiv \frac{\partial S/\partial v_i}{\partial S/\partial v_k} \cdot \frac{\partial v_i/\partial y_i}{\partial v_k/\partial y_k}. \tag{10}$$

We therefore obtain

$$\text{SMCF} = \frac{\sum_i \omega_i W_i h_i d\bar{a}_i}{\sum_i W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c \frac{dm_i}{d\bar{a}_i} + \phi_i\right)\right] d\bar{a}_i}. \tag{11}$$

2.2 Changes in tax rates

2.2.1 Progressivity preserving tax changes

A change in the progressive system of income taxation designed to raise one unit of tax revenue can take various forms. We follow Dahlby (1998) to specify such changes as those that maintain the three types of progressivity outlined by Musgrave and Thin (1948). However, our formulae below allow for heterogeneity within a single bracket that the original study assumed away in favor of homogeneity.

The first of the three alternative local measures of progressivity is the average rate progression (ARP), which is measured as

$$ARP_i \equiv \frac{m_i - a_i}{Y_i} \tag{12}$$

where m_i, a_i and Y_i are, respectively, the marginal tax rate, the average tax rate and pre-tax income. Holding Y_i constant, we maintain the ARP by setting tax changes such that $d\bar{a}_i = dm_i$. This condition is satisfied when $dm = dm_i \ \forall\ i$. We thus specify ARP-preserving SMCF as

$$SMCF_{APR} = \frac{\sum_i \omega_i W_i h_i}{\sum_i W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c + \phi_i\right)\right]} \tag{13}$$

which places the same weights on η_i^c and ϕ_i so that only the uncompensated elasticity ($\eta_i = \eta_i^c + \phi_i$) will affect this version of the SMCF.

The second is the liability progression (LP), which is measured as

$$LP_i \equiv \frac{m_i}{a_i}. \tag{14}$$

To keep LP_i, we set tax changes such that $dm_i/m_i = d\bar{a}_i/a_i \forall i$ which is satisfied when $dm/m =$

dm_i/m_i $\forall i$. We then obtain the LP-preserving SMCF as

$$\mathrm{SMCF}_{\mathrm{LP}} = \frac{\sum_i \omega_i W_i h_i}{\sum_i a_i W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c \frac{m_i}{a_i} + \phi_i\right)\right]}. \tag{15}$$

where more weight is placed on η_i^c than ϕ_i if the system has an LP i.e., $m_i/a_i > 1$.

The last is the residual income progression (RIP), which is defined as

$$\mathrm{RIP}_i \equiv \frac{1-m_i}{1-a_i}. \tag{16}$$

Then, RIP-preserving tax changes are such that $dm_i/(1-m_i) = d\bar{a}_i/(1-a_i)$ $\forall i$. Since the RIP is preserved if $dm/(1-m) = dm_i/(1-m_i)$ $\forall i$, the RIP-preserving SMCF is given as

$$\mathrm{SMCF}_{\mathrm{RIP}} = \frac{\sum_i \omega_i (1-a_i) W_i h_i}{\sum_i (1-a_i) W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c \frac{1-m_i}{1-a_i} + \phi_i\right)\right]} \tag{17}$$

where more weight is placed on ϕ_i than η_i^c if the tax system has an RIP, i.e., $(1-m_i)/(1-a_i) < 1$.

2.2.2 Region-specific SMCF

We can also compute the SMCFs by aggregating over a set of individuals who reside in the specific area r. Denoting that set of such individuals by $R(r)$, we define the region-specific SMCF as

$$\mathrm{SMCF}_{\mathrm{APR},r} = \frac{\sum_{i \in R(r)} \omega_i W_i h_i}{\sum_{i \in R(r)} W_i h_i \cdot \left[1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c + \phi_i\right)\right]} \tag{18}$$

for the ARP tax changes. Analogous definitions are obtained for the other two measures. Note that the region-specific SMCF will be relevant when funds for a public project are raised within the region where the project is implemented.

2.3 "Individual" MCF

When computing SMCFs, the distribution weights, ω_i, are required ingredients, which in turn necessitate that we specify the social welfare function. Since there may be no consensus about the specification of the social welfare function, we need to conduct a sensitivity analysis, as described below. Though such sensitivity analysis is useful, it also seems helpful to see the distribution of "components" of the SMCF before aggregation, i.e., the marginal cost of public funds for each individual. We define "individual" MCF in the following:

$$\text{Individual MCF}_i = \frac{1}{1 - \frac{m_i}{1-m_i} \cdot \left(\eta_i^c \frac{dm_i}{d\bar{a}_i} + \phi_i\right)} = 1 + \frac{\eta_i^c \frac{dm_i}{d\bar{a}_i} + \phi}{\frac{1-m_i}{m_i} - \eta_i^c \frac{dm_i}{d\bar{a}_i} + \phi_i}. \tag{19}$$

This "individual" MCF represents the marginal utility cost for an individual that will be generated if the government raises one additional unit of tax revenue from him. Note that we cannot construct the SMCFs, which are defined above, by summing up these "individual" MCFs, even with distributional weights. This is because the sum of the fraction is not equal to the fraction of the sum, i.e., $\sum(d\nu_i/dR_i)$ is not same as $(\sum d\nu_i)/(\sum dR_i)$.[2] Despite such characteristics, we believe that the computation of these "individual" MCFs has significant implications. One example is that the distribution of the "individual" MCF may suggest the distribution of marginal costs before they are aggregated with distributional weights.

As noted above, since a change in the progressive system of income taxation designed to raise one unit of tax revenue can take various forms, we consider three kinds of "individual"

[2] The former is the sum of 'individual' MCFs, while the latter is SMCF based on Benthamite social utility function.

MCFs here:

$$\text{Individual MCF}_{\text{APR},i} = 1 + \frac{\eta_i^c + \phi}{\frac{1-m_i}{m_i} - \eta_i^c + \phi_i}, \quad (20)$$

$$\text{Individual MCF}_{\text{LP},i} = 1 + \frac{\eta_i^c \frac{m_i}{a_i} + \phi}{\frac{1-m_i}{m_i} - \eta_i^c \frac{m_i}{a_i} + \phi_i}, \quad (21)$$

$$\text{Individual MCF}_{\text{RIP},i} = 1 + \frac{\eta_i^c \frac{1-m_i}{1-a_i} + \phi}{\frac{1-m_i}{m_i} - \eta_i^c \frac{1-m_i}{1-a_i} + \phi_i}. \quad (22)$$

3 Specifications

The calculation of the SMCF requires estimates of the compensated elasticity of labor η_i^c, income effect ϕ_i, the distributional weight ω_i, pre-tax income $W_i h_i$, the marginal tax rate m_i and the average tax rate a_i for *each individual.* This section explains how we constructed these parameter values.

3.1 Labor supply function

To obtain the estimates for compensated elasticities and income effects, we have estimated the following labor supply function with a variation of the maximum likelihood estimation by Hausman (1980):

$$h_i = \alpha w_i + \beta y_i + \mathbf{Z}_i \boldsymbol{\gamma} \quad (23)$$

where $\mathbf{Z}_i$ is a vector of individual characteristics. The details are provided in Bessho and Hayashi (2005). We have limited our attention to the sample of prime-age males (25–55), and the data are drawn from *Syugyo Kozo Kihon Chosa* [*Employment Status Survey*] put out by Statistics Bureau in 1997 and 2002. Although the estimates for the SMCF in the current study only represent the said group, we believe that our exercise would not be off the mark, since prime-age males constitute the major source of income tax revenues.

Estimates for the uncompensated elasticities $\hat{\eta}_i$ and the income effects $\hat{\phi}_i$ are obtained as follows.[3] While these values require point values for hours worked h_i, the data for hours worked are coded with intervals in our sample.[4] We therefore use predicated values for hours worked, i.e., $\hat{h}_i = \hat{\alpha} w_i + \hat{\beta} y_i + \mathbf{Z}_i \hat{\boldsymbol{\gamma}}$ where $(\hat{\alpha}, \hat{\beta}, \hat{\boldsymbol{\gamma}})$ are the estimated parameters for (23), and we calculate $\hat{\eta}_i$, $\hat{\phi}_i$ and $\hat{\eta}_i^c$ as $\hat{\eta}_i = \hat{\alpha} w_i / \hat{h}_i$, $\hat{\phi}_i = \hat{\beta} w_i$, and $\hat{\eta}_i^c = \hat{\eta}_i - \hat{\phi}_i$. Note that, given the specification (23), these values vary among observations. Table 2 provides summary statistics of our estimates for $\hat{\eta}_i$, $\hat{\phi}_i$ and $\hat{\eta}_i^c$. In 1997, the compensated elasticity ranges from .09 to .91 with the average being .34 and the standard error .11; the income effect ranges from $-.08$ to $-.79$ with the average $-.30$ and the standard error .10; and the uncompensated elasticity ranges from .01 to .11 with the average being .04 and the standard error .01[5]. As of 2002, the elasticities and income effect are estimated to be slightly larger than those in 1997.

3.2 Distributional weights

For distributional weight $\omega_i \equiv [(\partial S/\partial v_i)/(\partial S/\partial v_k)] \cdot [(\partial v_i/\partial y_i)/(\partial v_k/\partial y_k)]$, the individual utility function $v(\cdot)$ as well as the social welfare function $S(\mathbf{v})$ are to be specified. The labor supply function (23) is consistent with the following indirect utility function (Hausman 1980, Stern 1986)[6]:

$$v(w_i, y_i) = \exp[\beta w_i] \cdot \left(y_i + \frac{\alpha}{\beta} w_i - \frac{\alpha}{\beta^2} + \frac{\mathbf{Z}_i \gamma}{\beta} \right),$$

[3] Since our estimation is characterized with the piece-wise linear budget constraints and an explicitly parameterized preferences, we can identify individuals who consume at a kink point of his budget constraint. For such cases where we cannot define the elasticities, we obtain equivalent measures by the method shown in Bessho and Hayashi (2005).

[4] We have therefore modified Hausman's ML estimation to allow for the interval data. For more, see Bessho and Hayashi (2005). They have shown some estimation results and we employ here the cases where the variables about education are excluded.

[5] The linear specification of (23) restricts the values of elasticities a priori. That is, to the extent that w/h (w) is larger, the compensated elasticities (income effect) will be more positive (negative).

[6] For qualifications, see Stern (1986).

from which we can specify the marginal utility of income as

$$\frac{\partial v(w_i, y_i)}{\partial y_i} = \exp[\beta w_i]. \tag{24}$$

We specify the social welfare function as the celebrated type of constant inequality aversion (e.g., Bergson 1980, Boadway and Bruce 1984)

$$S = \sum_i \frac{{v_i}^{1-\theta}}{1-\theta}$$

where the constant inequality aversion (CIA) is measured with the parameter θ (Atkinson 1970). Specifically, this turns out to be Benthamite ($S = \sum_i v_i$) if $\theta = 0$, Nash ($S = \Pi_i v_i$) if $\theta \to 1$, and Rawlsian ($S = \min_i\{v_i\}$) if $\theta \to \infty$. Note that the CIA specification requires its arguments to be strictly positive. However, our estimates resulted in negative utility levels. To circumvent this incontinence, we perform a monotone transformation of v[7] with the normal cumulative distribution function $F(v)$[8] and redefine the social welfare as

$$S = \sum_i \frac{F(v_i)^{1-\theta}}{1-\theta}. \tag{25}$$

This yields the marginal social welfare of individual i's utility as

$$\frac{\partial S}{\partial v_i} = F(v_i)^{-\theta} F'(v_i)$$

which along with (24) allows us to specify the distributional weight as

$$\omega_i = \frac{F(v_i)^{-\theta}}{F(v_k)^{-\theta}} \cdot \frac{F'(v_i)}{F'(v_k)} \cdot \frac{\exp[\beta w_i]}{\exp[\beta w_k]} \tag{26}$$

[7] Of course, a monotone transformation does not alter the specification of labor supply function.

[8] This requires the first and second moments of v_i's. We used the sample average and the variance of estimated v_i's.

where individual k, as the reference, is taken as the one with the highest level of utility. Table 2 summarizes our estimates for the distributional weights obtained for three values of inequality aversion ($\theta = 0.001, 1.0, 2.0$). As expected, distributional weights become larger to the extent that the degree of inequality aversion gets larger.

4 Results

4.1 Progressivity preserving SMCF

Table 3 lists our estimates for the three types of the progressivity-preserving SMCFs (13)–(17). The results are summarized as follows. First, we do not find very large differences among the three. With our three values for inequality aversion ($\theta = 0.010, 1.0, 2.0$), the largest discrepancies are within 5%.

Second, a larger inequality aversion results in a higher SMCF, as expected. Note that all are more than unity since the "most blessed" individual is used as the reference. Of course, the value of the SMCF will change when we change the reference (i.e., individual k) for a given degree of inequality aversion. As such, we should be aware of who the reference individual is when we evaluate the values of the SMCF.

Third, our results may call for a careful application of distributional weights in project evaluation. For example, in an area where low-income residents are concentrated, the benefits of public projects will be evaluated more favorably compared to those in higher income areas. However, because the funds for the projects are raised through taxation, the same distributional weights must consistently be applied when we estimate the costs of the projects. If the funds are raised through national taxes, regional allocation of the projects may not be affected. But as far as distributional weights "blow up" the benefits of a project, they also blow up the cost of that project with the SMCF. Therefore, the use of distributional weights does not necessarily lead to a high benefit-cost ratio that we expect when we apply the distributional weights only to benefit evaluation.

We compute SMCF assuming the all distributional weights (ω_i) are equal to unity just as a reference, and the results are presented in Table 3. Such cases are not possible as long as they are based on Bergson-Samuelson social welfare function and the preference used in this paper. The results are, however, suggestive because we could interpret them as *MCPF*, rather than the SMCF. The value ranges from 1.003 to 1.141, which seems consistent with the results in Bessho et al.(2003).

4.2 Region-specific SMCF

We have calculated the region-specific SMCFs for the 47 prefectures in Japan. Table 4 lists the results, where each estimate is normalized by Tokyo. The SMCFs in the non-Tokyo regions are more than unity, implying that the SMCF is the smallest in Tokyo. This result is easily expected, since Tokyo is arguably the richest region, where the higher income residents are concentrated. As such, the SMCF would be smaller there since smaller distributional weights are placed on the rich.

For the other regions, however, the relative values of the SMCFs are different depending on the degree of inequality aversion as well as the type of progressivity-preserving SMCF. For example, while Tottori, Saga and Oita are the prefectures with the highest SMCFs when the Benthamite social welfare function ($\theta = 0$) is employed, Aomori, Iwate and Okinawa replace those prefectures when the Nash specification ($\theta \to 1$) is used in 1997. On the other hand, the order of the regions with lower SMCFs is stable. For example, the lowest three are Tokyo, Kanagawa and Osaka over different combination of inequality aversion and progressivity preserving tax changes.

With the region-specific SMCFs, some experiments are possible following Dahlby and Wilson (1990). If Japan were a federal state where the said 47 prefectures raised taxes independently, the results in Table 4 suggest that transfers from Tokyo to the other regions would be socially desirable since Tokyo's SMCF is the lowest, and such transfers would reduce SMCFs in other regions.

4.3 "Individual" MCF

Figure 1 is the estimated distribution of the "Individual" MCFs, which shows that most of the values cluster between 1.00 and 1.02 in 1997. As of 2002, the distribution is skewed to the right of 1997, because the estimated labor elasticities in 2002 are larger than those in 1997. Nonetheless, the values of 2002 distribute mainly between 1.00 and 1.08.

Figure 2 shows the estimated distribution of the "Individual" MCFs of each person's income class. The peaks of the distribution tend to move rightwards, which suggests that the MCF becomes larger as income increases. This is also because the elasticities of the labor supply are estimated to be larger for higher income classes. "Individual" MCFs of each region are shown in Figure 3. All lines except that of Kanto are almost the same. The distribution of the MCFs for the Kanto area is flatter than the others, since the Kanto area includes Tokyo, where higher income residents are concentrated as noted above.

5 Concluding Remarks

This paper extends Dahlby (1998)'s theoretical contribution to the social marginal cost of public funds and calculates the SMCFs for various cases with the microdata on Japanese prime-age males. First, we derive several formulae for the SMCF that take advantage of our household data. Second, taking advantage of our estimation of the labor supply of prime-age male workers, we construct the data necessary to calculate the SMCFs. Third, taking advantage of our formulae, we present several types of SMCF, including (a) three types of progressivity-preserving SMCF, (b) region-specific SMCF, and (c) the "individual" MCF. We then discuss some of the policy implications thereof. Note however that our estimates are based upon a sample of prime-age males, each of whom is the only worker in his household. Although we can justify the use of such a sample by saying that tax contributions by prime-age males comprise a substantive portion of tax revenues, our estimates are limited to the extent that other type of excluded workers affect total tax revenues. However, some type of workers may not even fit the theoretical framework for the SMCF formula in the first place. For example, the standard framework may not allow for the case where more than one household member works and incomes are shared. Allowing for this possibility, both theoretically and empirically, is the task for our future research.

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Table 1: Outline of income taxation system

(Thousand yen)

	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 A1-a: 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 A1-b: 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 A2: Estimation Results

	1997	1997	2002	2002
After-tax wage rate	292.949	822.254	903.005	1262.919
	(72.29)	(97.98)	(95.80)	(110.12)
Virtual income	-1.293	-1.426	-2.510	-2.799
	(0.18)	(0.21)	(0.31)	(0.32)
Age	4.206	2.684	14.062	14.163
	(2.58)	(2.63)	(3.23)	(3.28)
Age^2	-0.138	-0.154	-0.265	-0.287
	(0.03)	(0.03)	(0.04)	(0.04)
# of kids younger than 15	9.161	8.538	9.802	9.344
	(2.10)	(2.14)	(2.66)	(2.69)
# of Specific dependent children	-15.668	-16.704	-11.194	-10.145
	(3.49)	(3.59)	(4.31)	(4.39)
Junior high school		115.111		120.336
		(6.24)		(8.00)
2-year college		4.051		2.438
		(7.78)		(8.58)
4-year college		-12.491		-1.688
		(6.51)		(7.49)
Constant	1757.746	1734.557	1554.371	1514.132
	(50.02)	(50.80)	(63.04)	(63.93)
s_h	329.765	332.706	347.471	340.389
	(17.12)	(15.70)	(16.42)	(15.20)
s_e	249.094	249.510	321.022	329.660
	(21.35)	(19.88)	(16.16)	(13.90)
# of observation	73713	73697	63717	63703
Log Likelihood	-73666.7	-73472.446	-68272.28	-68136.86

(Note) Figures in parentheses shows standard error.

Table A3: Estimated Elasticity

	Average	Std. err.	max	min
1997, without education variables				
h	0.040	0.014	0.114	0.011
f	-0.301	0.096	-0.084	-0.793
h_c	0.341	0.110	0.907	0.095
1997, with education variables				
h	0.113	0.039	0.309	0.031
f	-0.332	0.106	-0.093	-0.874
h_c	0.445	0.145	1.183	0.123
2002, without education variables				
h	0.113	0.041	0.311	0.029
f	-0.556	0.194	-0.143	-1.440
h_c	0.668	0.234	1.751	0.172
2002, with education variables				
h	0.158	0.057	0.435	0.041
f	-0.620	0.216	-0.159	-1.607
h_c	0.778	0.272	2.042	0.201

Table 2a: Elasticities, distributional weights, 1997

Without education variables	average	Std. dev	min	max
Hours worked	1531.85	516.28	0.00	1856.16
Average tax rate	0.19	0.03	0.00	0.28
Marginal tax rate	0.24	0.05	0.00	0.37
h_c	0.34	0.11	0.09	0.91
f	-0.30	0.10	-0.79	-0.08
$h=h_c+f$	0.04	0.01	0.01	0.11
w_i: θ=0.001	407.48	163.05	1.00	578.58
w_i: θ=1.0	1382.88	994.16	1.00	5459.02
w_i: θ=2.0	12338.65	33257.34	1.00	1688923.00

Table 2b: Elasticities, distributional weights, 2002

Without education variables	average	Std. dev	min	max
Hours worked	1612.89	518.67	0.00	2189.72
Average tax rate	0.18	0.02	0.00	0.25
Marginal tax rate	0.21	0.05	0.00	0.36
h_c	0.67	0.23	0.17	1.75
f	-0.56	0.19	-1.44	-0.14
$h=h_c+f$	0.11	0.04	0.03	0.31
w_i: θ=0.001	262.66	108.51	1.00	376.85
w_i: θ=1.0	927.66	716.98	1.00	4107.30
w_i: θ=2.0	10649.11	44958.95	1.00	1540978.00

Table 3a. Progressivity preserving SMCF, 1997

		Degree of inequality aversion		
	w = 1	0.001	1	2
ARP	1.017	399.94	1170.53	8342.18
LP	1.077	415.91	1162.68	7815.51
RIP	1.003	396.43	1172.25	8457.86
S	—	0.49	—	-4.68

(Note) Elasticities are calculated based on the estimation without education variables.

Table 3b. Progressivity preserving SMCF, 2002

		Degree of inequality aversion		
	w = 1	0.001	1	2
ARP	1.042	259.27	752.27	5799.11
LP	1.141	277.60	772.03	5553.46
RIP	1.023	255.74	748.70	5850.82
S	—	0.50	—	-5.21

(Note) Elasticities are calculated based on the estimation without education variables.

Table 4a: SMCF for each region, 1997

		ARP			LP			RIP		
		0.001	1	2	0.001	1	2	0.001	1	2
1	Hokkaido	1.59	2.71	6.90	1.55	2.59	6.58	1.61	2.74	6.97
2	Aomori	1.55	3.63	15.98	1.51	3.47	15.41	1.57	3.66	16.10
3	Iwate	1.54	3.53	14.41	1.49	3.36	13.79	1.56	3.57	14.54
4	Miyagi	1.52	2.24	4.91	1.48	2.15	4.67	1.53	2.26	4.96
5	Akita	1.59	3.18	11.93	1.53	3.01	11.36	1.60	3.22	12.05
6	Yamagata	1.61	3.29	11.86	1.56	3.14	11.28	1.62	3.33	11.98
7	Fukushima	1.60	2.97	8.66	1.56	2.83	8.22	1.62	3.00	8.76
8	Ibaraki	1.48	1.84	2.80	1.44	1.77	2.64	1.49	1.85	2.83
9	Tochigi	1.60	2.30	4.37	1.56	2.20	4.13	1.61	2.32	4.42
10	Gumma	1.60	2.55	6.24	1.56	2.45	5.94	1.61	2.58	6.30
11	Saitama	1.37	1.71	2.71	1.34	1.65	2.58	1.38	1.73	2.74
12	Chiba	1.34	1.66	2.66	1.31	1.60	2.53	1.35	1.67	2.68
13	Tokyo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	Kanagawa	1.23	1.38	1.74	1.21	1.36	1.72	1.24	1.39	1.75
15	Niigata	1.62	2.73	7.40	1.57	2.63	7.16	1.63	2.76	7.46
16	Toyama	1.60	2.55	6.49	1.56	2.44	6.11	1.61	2.58	6.57
17	Ishikawa	1.60	2.55	6.31	1.56	2.44	6.00	1.61	2.57	6.39
18	Fukui	1.59	2.75	7.31	1.54	2.63	6.98	1.60	2.78	7.38
19	Yamanashi	1.57	2.39	4.88	1.53	2.29	4.62	1.58	2.42	4.94
20	Nagano	1.60	2.29	4.41	1.56	2.20	4.27	1.61	2.31	4.44
21	Gifu	1.63	2.51	5.59	1.59	2.40	5.30	1.64	2.53	5.66
22	Shizuoka	1.57	2.27	4.56	1.53	2.17	4.29	1.58	2.30	4.62
23	Aichi	1.41	1.74	2.47	1.38	1.69	2.40	1.42	1.75	2.49
24	Mie	1.52	2.01	3.35	1.48	1.93	3.18	1.53	2.03	3.39
25	Shiga	1.45	1.82	2.82	1.42	1.76	2.74	1.46	1.83	2.84
26	Kyoto	1.39	1.80	3.05	1.37	1.74	2.90	1.40	1.82	3.08
27	Osaka	1.31	1.53	2.08	1.28	1.49	2.00	1.31	1.55	2.10
28	Hyogo	1.40	1.77	2.95	1.37	1.70	2.81	1.41	1.79	2.99
29	Nara	1.38	1.75	2.88	1.34	1.68	2.73	1.39	1.77	2.92
30	Wakayama	1.60	2.51	5.89	1.56	2.40	5.48	1.61	2.54	5.98
31	Tottori	1.65	3.01	9.33	1.59	2.88	8.91	1.66	3.04	9.42
32	Shimane	1.60	3.11	9.75	1.54	2.97	9.41	1.61	3.15	9.83
33	Okayama	1.56	2.27	5.01	1.51	2.16	4.70	1.57	2.30	5.08
34	Hiroshima	1.53	2.08	3.69	1.49	2.00	3.54	1.54	2.10	3.73
35	Yamaguchi	1.61	2.34	4.74	1.57	2.24	4.48	1.63	2.36	4.79
36	Tokushima	1.60	2.66	7.00	1.56	2.54	6.53	1.62	2.69	7.11
37	Kagawa	1.57	2.26	4.70	1.53	2.17	4.43	1.58	2.29	4.76
38	Ehime	1.63	2.89	7.36	1.59	2.75	6.90	1.65	2.92	7.46
39	Kochi	1.61	3.00	9.75	1.56	2.86	9.26	1.62	3.03	9.85
40	Fukuoka	1.53	2.19	4.21	1.49	2.10	4.01	1.54	2.21	4.25
41	Saga	1.63	2.96	8.44	1.58	2.82	7.96	1.64	2.99	8.54
42	Nagasaki	1.60	2.97	8.71	1.55	2.82	8.19	1.61	3.01	8.81
43	Kumamoto	1.60	2.84	7.54	1.55	2.72	7.20	1.61	2.87	7.61
44	Oita	1.64	2.88	7.84	1.59	2.75	7.39	1.65	2.92	7.94
45	Miyazaki	1.59	3.15	10.73	1.54	2.99	10.15	1.61	3.18	10.85
46	Kagoshima	1.60	3.04	9.00	1.55	2.90	8.50	1.61	3.08	9.11
47	Okinawa	1.45	3.81	22.27	1.40	3.62	21.11	1.46	3.85	22.49

Table 4b: SMCF for each region, 2002

		ARP			LP			RIP		
		0.001	1	2	0.001	1	2	0.001	1	2
1	Hokkaido	1.98	3.69	10.03	1.75	3.24	9.02	2.04	3.79	10.24
2	Aomori	1.95	4.78	18.46	1.72	4.20	16.57	2.01	4.92	18.89
3	Iwate	1.94	4.82	20.40	1.71	4.22	18.22	2.00	4.95	20.85
4	Miyagi	1.92	3.01	6.82	1.71	2.66	6.04	1.97	3.09	6.98
5	Akita	1.98	4.59	17.59	1.74	4.03	15.79	2.04	4.73	18.02
6	Yamagata	1.92	4.24	16.43	1.69	3.70	14.69	1.98	4.37	16.82
7	Fukushima	1.96	3.84	10.41	1.73	3.40	9.53	2.02	3.95	10.63
8	Ibaraki	1.71	2.28	3.68	1.55	2.07	3.34	1.74	2.33	3.76
9	Tochigi	1.89	2.70	5.01	1.70	2.42	4.52	1.93	2.76	5.12
10	Gumma	1.92	3.03	6.05	1.71	2.70	5.40	1.97	3.11	6.19
11	Saitama	1.72	2.39	4.33	1.55	2.15	3.86	1.76	2.45	4.43
12	Chiba	1.61	2.00	2.74	1.47	1.82	2.53	1.64	2.04	2.78
13	Tokyo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	Kanagawa	1.39	1.57	1.94	1.30	1.48	1.82	1.40	1.60	1.97
15	Niigata	2.02	3.81	9.41	1.78	3.37	8.62	2.08	3.91	9.60
16	Toyama	1.93	3.26	7.45	1.71	2.89	6.71	1.98	3.35	7.61
17	Ishikawa	1.96	3.27	6.87	1.74	2.89	6.21	2.01	3.35	7.01
18	Fukui	1.97	3.21	6.10	1.75	2.85	5.49	2.02	3.29	6.23
19	Yamanashi	1.81	2.66	4.61	1.63	2.37	4.14	1.86	2.72	4.71
20	Nagano	1.95	3.09	5.54	1.73	2.74	5.02	2.00	3.17	5.65
21	Gifu	1.94	3.18	6.96	1.72	2.80	6.16	1.99	3.26	7.13
22	Shizuoka	1.83	2.73	5.38	1.64	2.44	4.84	1.87	2.80	5.49
23	Aichi	1.69	2.14	2.96	1.54	1.95	2.74	1.73	2.18	3.01
24	Mie	1.82	2.48	3.84	1.64	2.23	3.48	1.86	2.53	3.92
25	Shiga	1.67	2.20	3.53	1.52	2.00	3.24	1.71	2.24	3.59
26	Kyoto	1.66	2.27	4.21	1.50	2.04	3.79	1.69	2.32	4.29
27	Osaka	1.53	1.85	2.63	1.42	1.71	2.41	1.56	1.89	2.68
28	Hyogo	1.69	2.24	3.67	1.54	2.02	3.30	1.73	2.29	3.75
29	Nara	1.62	2.07	3.51	1.47	1.88	3.17	1.66	2.11	3.58
30	Wakayama	1.94	3.26	7.89	1.72	2.88	7.00	1.99	3.35	8.07
31	Tottori	1.94	3.80	11.86	1.72	3.35	10.55	2.00	3.91	12.15
32	Shimane	1.94	4.31	16.24	1.71	3.79	14.42	1.99	4.43	16.63
33	Okayama	1.92	2.90	5.08	1.71	2.59	4.63	1.96	2.97	5.17
34	Hiroshima	1.74	2.36	4.00	1.57	2.13	3.64	1.78	2.41	4.08
35	Yamaguchi	1.92	2.94	5.49	1.71	2.60	4.93	1.97	3.02	5.60
36	Tokushima	1.93	3.06	6.17	1.72	2.72	5.59	1.98	3.13	6.29
37	Kagawa	1.96	3.36	8.91	1.74	2.96	7.79	2.02	3.46	9.17
38	Ehime	1.97	3.18	6.62	1.75	2.81	5.93	2.02	3.26	6.77
39	Kochi	1.87	3.80	12.21	1.65	3.33	10.91	1.93	3.93	12.54
40	Fukuoka	1.81	2.60	4.62	1.63	2.34	4.20	1.86	2.66	4.71
41	Saga	1.99	3.54	8.40	1.77	3.13	7.60	2.06	3.65	8.61
42	Nagasaki	2.04	3.71	9.22	1.80	3.28	8.17	2.10	3.82	9.48
43	Kumamoto	1.95	3.47	9.80	1.72	3.05	8.64	2.01	3.57	10.06
44	Oita	1.99	3.60	9.54	1.76	3.17	8.52	2.05	3.70	9.76
45	Miyazaki	1.97	4.22	14.31	1.74	3.71	12.80	2.02	4.34	14.65
46	Kagoshima	2.02	3.80	9.13	1.78	3.34	8.19	2.08	3.90	9.33
47	Okinawa	1.85	5.19	36.33	1.62	4.54	32.46	1.91	5.35	37.16

Figure 1. Individual MCF

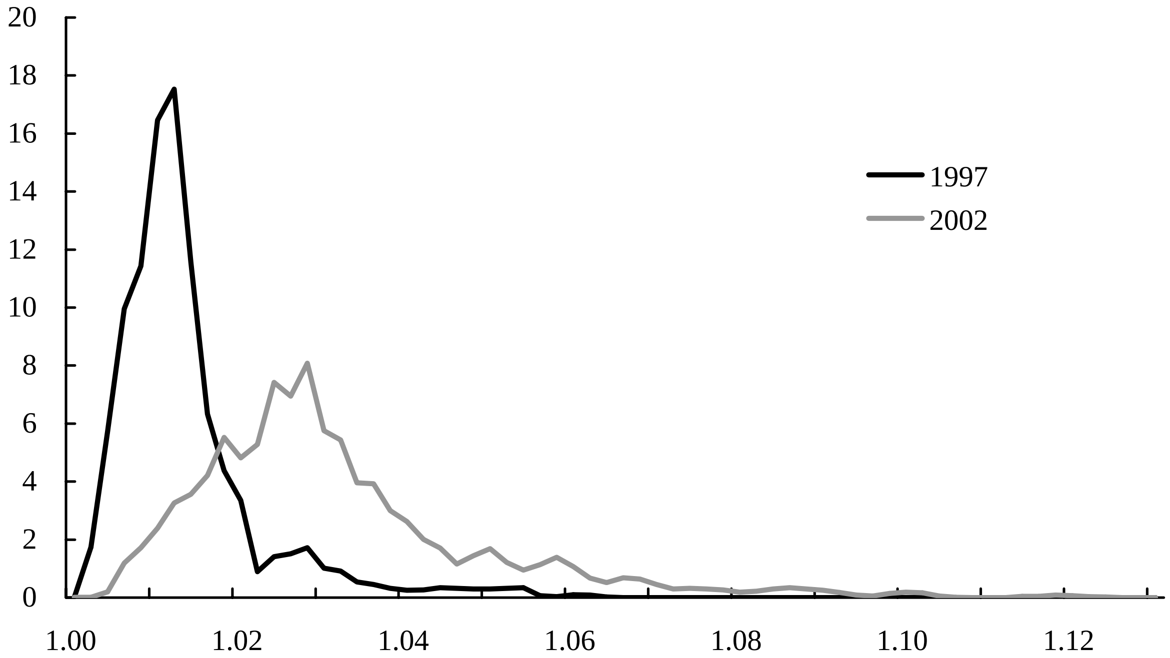

Figure 2a. `Individual' MCF for Each Income Class, 1997

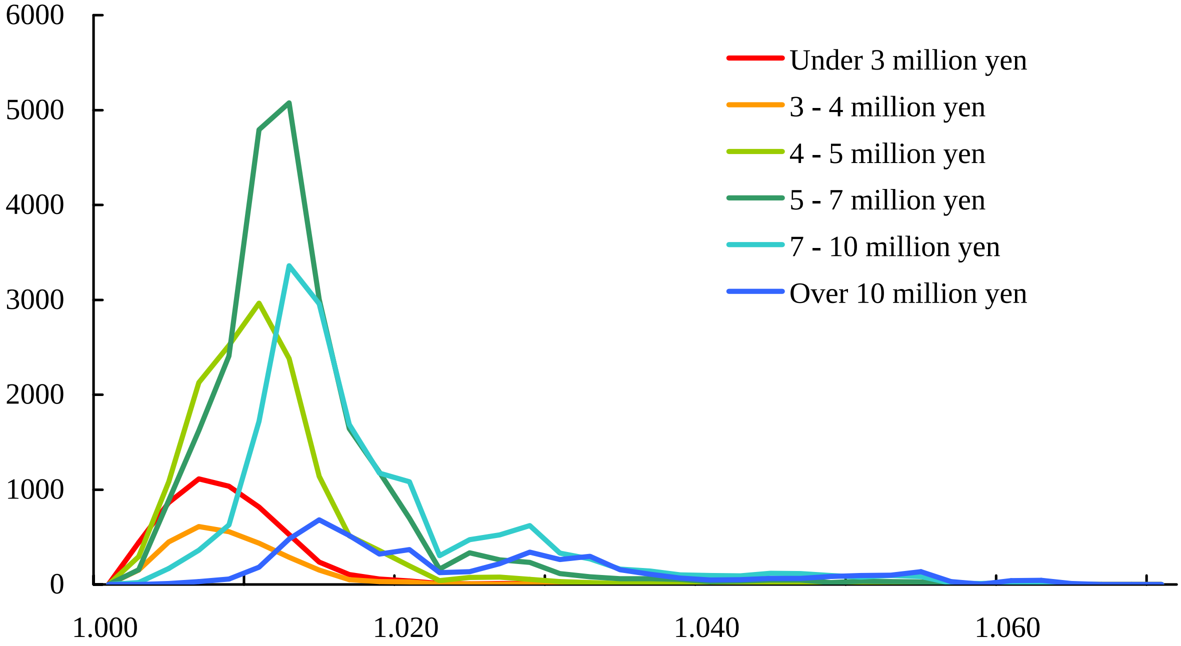

Figure 2b. `Individual' MCF for Each Income Class, 2002

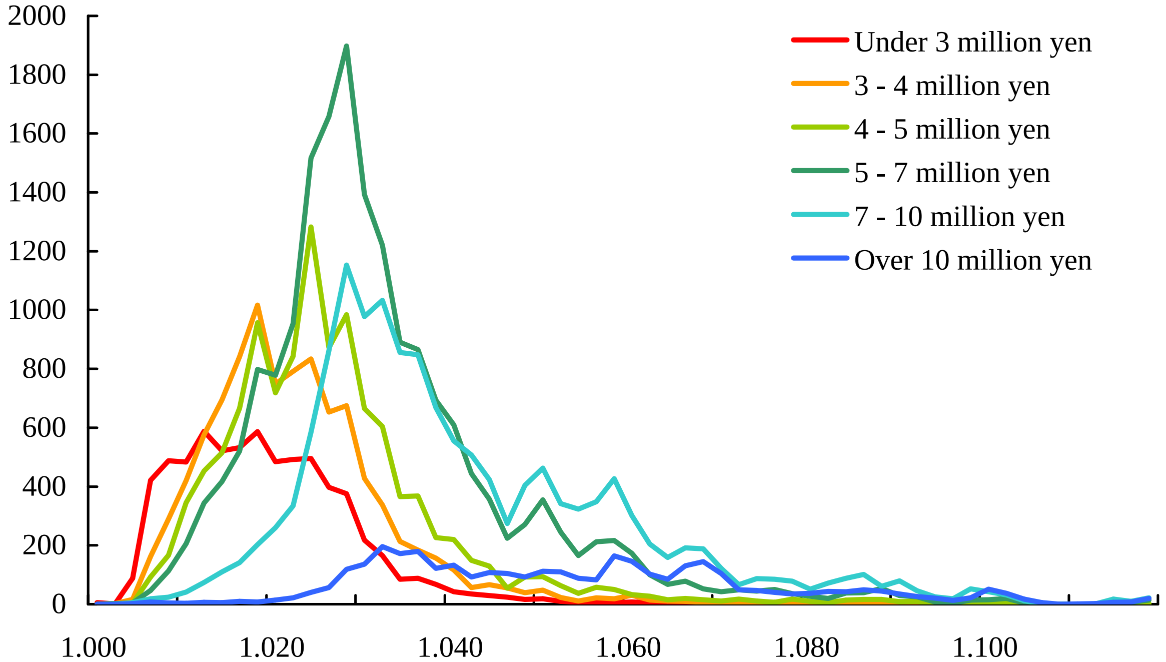

Figure 3a. `Individual' MCF for Each Region, 1997

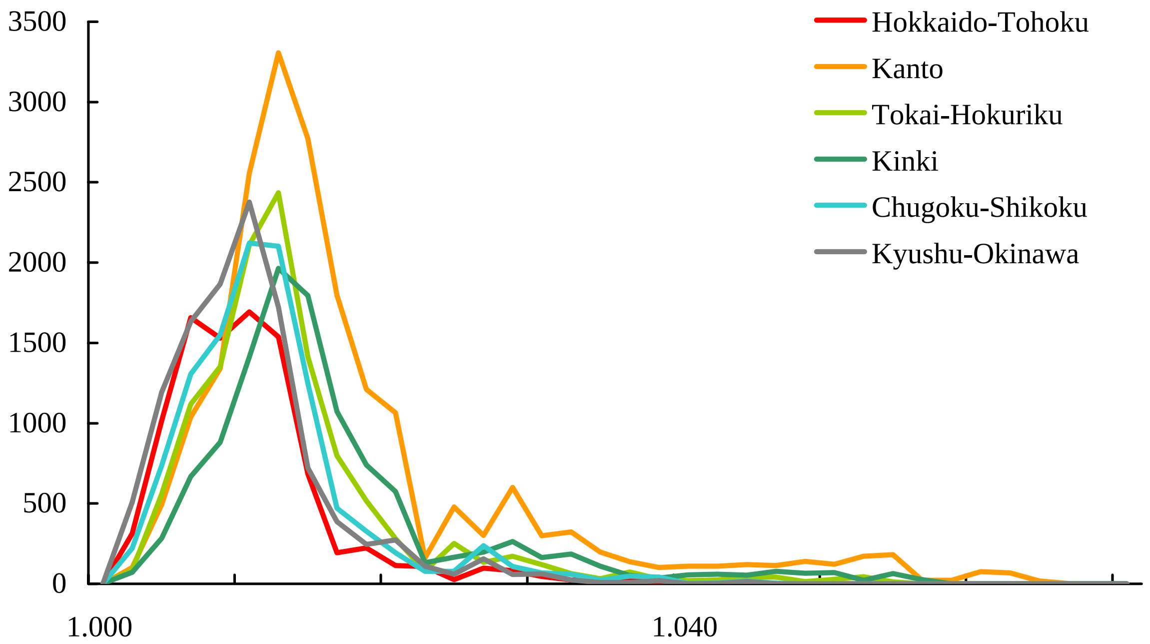

Figure 3b. `Individual' MCF for Each Region, 2002