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Property Taxation and the Demand for Floor Space in Japan

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This is the first study applying the econometric analysis of piecewise-linear budget constraints arising from space-linked property taxation to Japanese housing data. The model employed is the classical Hausman type with convex piecewise-linear budget constraints and fixed preferences. We estimate that if spaced-linked property taxation for newly built houses is abolished, it would then eliminate a current excess tax burden per household of approximately 25,000 yen.

Keywords

Nonlinear budget constraints, Property taxation, Housing demand, Floor space, Japan.

Introduction

In this paper we will study the effects of Japanese differential property tax treatment. At present, the property tax rate for newly built houses of floor space up to a certain range is lower than the usual rate. This difference is important given the fact that the market for used houses is small when compared with the market for newly built houses[1]. Since the ratio of newly built houses that are purchased is larger than those obtained by other means,

[1] *Housing Survey of Japan* (Statistics Bureau, 1993) reports that among the total houses purchased during the 1988 to 1993 period in Japan, only 2.5% is for used houses while the portion for newly built houses is approximately 39.7%.

the current Japanese property taxation system could potentially distort the purchasing decisions of home buyers. We will analyze the effects of those space-linked property taxation on consumers' floor space demand by explicitly considering nonlinearities in budget constraints and calculate the excess burden on each household created by the present property taxation system. In addition, we will propose some modifications to the present Japanese property taxation system that will remove any such distortions.

This is the first study to apply the econometric analysis of piecewise-linear budget constraints arising from space-linked property taxation to Japanese housing data. The model employed is the classical Hausman type with convex piecewise-linear budget constraints and fixed preferences. Although there have been several housing studies in Japan and the U.S. that explicitly consider nonlinearities in budget constraints, these nonlinearities arise due to the space-linked subsidized interest rates of Japan Housing Loan Corporation [see Seko (1993, 1994, 1996)] and also to such government programs as housing gap plans [see Hausman and Wise (1980)], moving costs [see Venti and Wise (1984)] and progressive income taxes [see MacRae and Turner (1981)]. In our paper, the nonlinearities come from the space-linked property taxation. The space-linked property taxation system is unique to Japan as far as I know and thus this is the first study to address this type of nonlinearity.

The organization of the remainder of this paper is as follows. Section 2 presents a nonlinear budget constraint arising from property taxation and some evidence based on data analysis. Section 3 discusses the data sources and defines the variables. Section 4 presents a structural form estimation model of floor space demand when an explicit nonlinear budget constraint is specified. Section 5 presents policy simulations and analyzes efficiency effects by measuring deadweight loss. Section 6 offers our concluding remarks.

Nonlinear Budget Constraints Arising from Property Taxation

At present, in Japan, the property tax rate for newly built houses of floor space between 40 m^2 and 200m^2 is lower than the usual tax rate. The tax reduction eligibility applies to newly built houses of up to 200m^2 , but the actual reduction rate applies only to floor space from 40m^2 to 120m^2 . The remainder is taxed at the same rate as houses of over 200m^2 and second-hand houses , for which there is no such reduction.

We assume consumers obtain utility from housing services *h* and other goods *C*. Housing services *h* consists of all the things one considers when purchasing a home. We divide housing services h into two categories, quantity of floor space, F, and all other attributes, I, which we will call quality. That is, $h = h(F,I)$.

For newly built houses the consumer budget constraint is

$$Y = C + (r + de - p)P_H(I)F + 0.5tP_H(I)\overline{F} + tP_H(I)(F - \overline{F}) \quad (1)$$
$$(40 \le F \le 200,\ 40 \le \overline{F} \le 120),$$

where Y is real permanent income, r is interest rate, de is the depreciation rate, t is the property tax rate, p is inflation rate, $P_H(I)$ is the real unit price of housing and assumed to depend upon quality I. $\overline{F}$ is the tax reduction eligible floor space. We assume property tax rate t is reduced to half for eligible newly built houses. This property tax reduction is presented in the third and fourth terms of the right-hand side of equation (1).
As for other kinds of houses the budget constraint becomes:

$$Y = C + (r + de + t - p)P_H(I)F \quad (2)$$

The budget constraint defined by (1) and (2) is portrayed in Figure 1 in (C, F) space by assuming I is constant. The Japanese property taxation creates three kinks (40m^2, 120m^2, 200m^2) in the budget constraint. Here,

$$UC(I) = \begin{cases} (r + de + 0.5t - p)P_H(I) & for\ 40 \le F \le 120 \\ (r + de + t - p)P_H(I) & for\ 120 < F \end{cases} \quad (3)$$

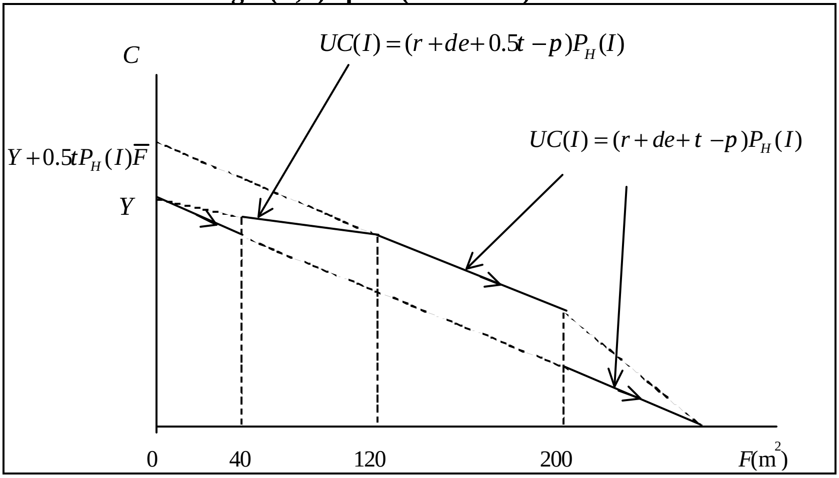
and,

$$\tilde{Y} = \begin{cases} Y & for\ 40 \le F \le 120, F > 200 \\ Y + 0.5tP_H(I)\overline{F} & for\ 120 \le F \le 200 \end{cases} \quad (4)$$

where $UC(I)$ is the real user cost of capital of owner-occupied housing (i.e. floor space) and $\tilde{Y}$ is the value of the vertical intercept.

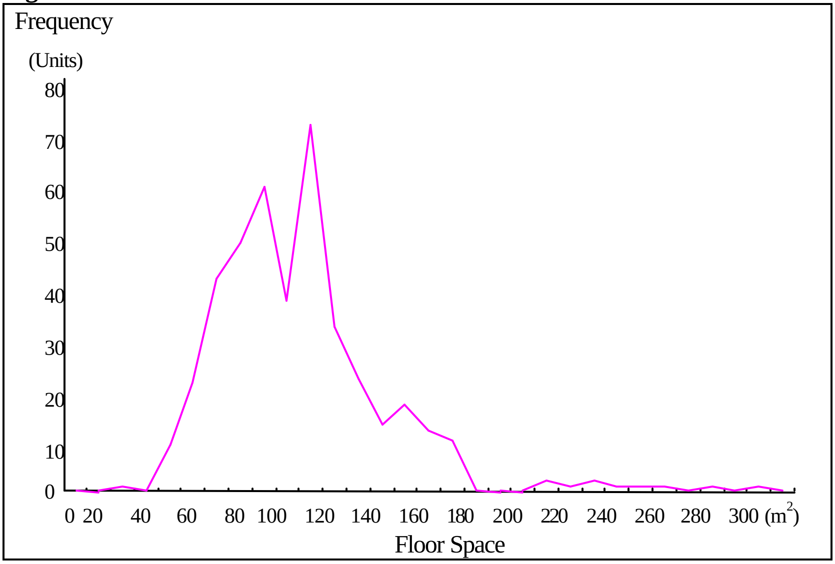
Figure 2 shows the frequency distribution of housing floor space. Casual observation indicates that space-linked property taxation has a powerful effect on the distribution of floor space demand, because demand for floor space levels are much greater around 110m^2 levels which are close to the kinks points of the nonlinear budget constraints in Figure 1 .

Fig.1 Floor Space Demand Model
Nonlinear Budget (C,F) Space (I Constant)



Notes: F=floor space; C=composite goods; Y=real income; $UC(I)$=the real user cost of capital of owner-occupied housing; $P_H(I)$=the real unit price of housing; I=quality of housing; r=interest rate; de=the depreciation rate; t=the property tax rate; p=inflation rate; $\overline{F}$ =the tax reduction eligible floor space.

Fig.2 Floor Distribution



Data Consideration

Our primary data source is the Housing Demand Survey of 1993 for the Tokyo Metropolitan Area conducted by the Ministry of Construction. This survey represents a sample of households in 1993 and includes the following variables for all households: date of move to present living quarters, tenure of present dwelling, number of members in the household, number of rooms in the present residence, current income, place of present residence, commuting time, age of the head of the household and housing costs. In addition to the variables available for all households, the Survey includes additional information on recent movers -- specifically households that moved into their present dwelling after 1989 (i.e. "recent movers"). For recent movers, the Survey includes the following variables in previous residence: status of previous residence, number of household members, number of rooms, household type and housing costs. The sample is limited to recent movers. I exclude from the sample households which the Survey shows as having changed their residence without also indicating a change of location. That is, I exclude the sample households which have rebuilt their houses at the same places.

The unit price of owner-occupied housing, $\overline{\overline{P}}_H$, was constructed from construction and land price data based on the following formula,

$$\ln \overline{\overline{P}}_H = k_L \ln p_L + (1-k_L)\ln p_N \qquad (5)$$

where p_L is land price per square meter of lot, p_N is construction cost per square meter of floor space and k_L is the ratio of the value of the structure to the total value of the house. We assumed k_L is 0.5 based on the average in the Survey. For p_L we use data from *the Survey of Prefectural Land Prices* (Land Agency). For p_N we use data from the *Construction Statistics Yearbook* (Ministry of Construction). p_L is city, town or village specific and p_N is prefecture[2] specific. That is, each household in the sample was assigned p_L and p_N for the prefecture, city, town, or village in which it resides. The data for all these variables is taken from the year that each household has moved to the present owner-occupied dwelling.

Next, we calculate the housing stock, *H(F,I)*, which is assumed to depend on *F* and ***I*,** as follows:

$$H(F,I) = \frac{P_H(I)F}{\overline{\overline{P}}_H} \qquad (6)$$

where $P_H(1)F$ is the purchase price paid by each household from the Survey. *H(F,I)*, as constructed above, is the quality adjusted quantity, capturing

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[2] It corresponds to British county.

quality variations other than location-specific land and construction price variations. As housing services *h(F,I)* is proportional to *H(F,I)*, the quantity of housing services consumed by each household will also be a quality adjusted quantity.

We construct the quality index, *I*, by dividing, *H(F,I)*, by quantity *F*, the floor space, and then substituting (6) to obtain:

$$I = \frac{H(F,I)}{F} = \frac{P_H(I)F / \overline{\overline{P}}_H}{F} = \frac{P_H(I)}{\overline{\overline{P}}_H} \qquad (7)$$

From (7), $P_H(I) = I \times \overline{\overline{P}}_H$ where we assume I is constant.

As for the user cost of capital *UC*(*I*) in (3), r was set at the private housing loan rate at the time of entering the present dwelling, *de* to 0.0255 for wooden houses and 0.01395 for nonwooden houses and, π, to the rate of increase of the residential housing deflator. The effective tax rate, t , was derived based on each prefecture's effective land and structure property tax rate as follows:

$$t = [k_L \times (\textit{property tax assessment value} / \textit{market value}) + k_N \times 0.7] \times 0.014 \qquad (8)$$

Each household in the sample was assigned *UC*(*I*) based on its floor space according to (3).

Since we only know current income, i.e. income in the survey year, we constructed income at the time of move by deflating current income by the CPI. It may be appropriate to construct permanent income data for *Y* if data becomes available, but as we only have the means from each income bracket, I used current income due to data limitations.

Real income and real user cost are constructed by dividing this deflated income and nominal user cost by the price of other goods and services, *Q*. The data for *Q* are taken from the *National Survey of Prices*. *Q* is city, town or village specific and taken from the time of relocation to the present dwelling. That is, each household in the sample was assigned *Q* for the city, town, or village in which it resided at the time of move.

As for socioeconomic variables, we use the age of the head of household and the number of household members. Table 1 provides descriptive statistics of the data set and summarizes the characteristics of the sample. Average nominal income per household is about 8,120,000 yen and average floor space of owner-occupied house per household is about 91 m^2.

Table 1: Characteristics of Data

Sample size	403.00
Age of head (years old)	40.90 (9.6)
Unit price of owner-occupied housing (per squared meter)($\overline{\overline{P}}_H$) (10 thousand yen)	26.40 (11.1)
Income(nominal) (10 thousand yen)	812.70 (307.6)
Virtual income(real)(VY)* (10 thousand yen)	7.60 (2.8)
Virtual user cost of capital of owner-occupied housing (VUC(I))* (yen)	32.00 (17.0)
Household member (person)	3.51 (1.3)
Floor space(F) (m^2)	91.00 (35.7)
Quality (I)	0.21 (0.086)

Note: Numbers in parentheses are standard errors.
*See section 4 for definitions of VY and VUC(I).

Estimation Model

We specify the floor space demand function as:

$$F = F^* + e_F = a_0 + a_1 UC(I) + bY + a_3 D + e_F \qquad (9)$$

where F^* is desired floor space, D denotes demographic variables , $?_F$ is a stochastic term with mean zero and a_0, a_1, b, a_3 are all parameters.

The unique feature of our model is our inclusion of nonlinear budget constraints caused by the space-linked property taxation. In this paper, we will follow the piecewise linear approach developed by Hausman and others. [See Hausman (1979, 1985), Moffitt (1990) and Pudney (1989).]

The advantages of this approach over the simple reduced form estimation of demand functions are numerous. Firstly, we have shown that there are many observations at kink points in the data analysis. [See Figure 2.] Ignoring observations at these kinks will probably lead to a selection bias. Secondly, the simple reduced form estimation is an unsatisfactory approach because OLS estimates will be inconsistent. The error term in the floor demand equation will be correlated with right hand side variables such as income and price variables, because they are partly selected by the individual in their choice of segment. Thirdly, we need to know the consumer's preferences or, equivalently, its utility function for the comparative statics. Note that the comparative statics of consumer demand in the usual sense holds up in the presence of kinked budget sets only *within* segments.

We examine the floor space demand model with fixed preferences and convexified budget constraints. We assume a_0, a_1, b, a_3 are the same for all individuals. Desired floor space will usually depend on the complete vectors of both virtual prices (in this case virtual user cost) and virtual incomes. For simplicity, we convexify the budget set by taking its convex hull. A floor space demand model should include individual maximization of utility over the nonlinear budget set and account properly for the multiplicity of virtual user cost and virtual incomes.

Since the budget set is convex and preferences are strictly convex, there exists a unique global maximum to the individual's utility maximization problem for the desired floor space. We need only ascertain where the tangency occurs. The problem to be solved in econometric estimation is to find desired floor space, F^*, when the individual is faced with the convex budget set, with m linear segments, J_k, for k=1,…,m. To find F^*, the specification of desired floor space on a given budget segment, J_k, is taken:

$$F_k^* = f(VUC(I)_{[k]}, VY_{[k]}) = a_0 + a_1 VUC(I)_{[k]} + b\,VY_{[k]} + a_3 D \qquad (10)$$

For each extended segment of the individual's budget constraint, we can calculate the desired floor space, $F_k^* = f(VUC(I)_{[k]}, VY_{[k]})$. The budget set is described by, $C = VY_{[k]} - VUC(I)_{[k]} F_k^*$ where $VUC(I)_{[k]}$ is the virtual real user cost corresponding to the k-th segment and $VY_{[k]}$ is the corresponding virtual income. Let $F_{[k]}$ represent the amount of floor space at the first kink point in segment k, see Figure 1. If we compute $F_k^* = f(VUC(I)_{[k]}, VY_{[k]})$ and find $F_k^* \in J_k \; where J_k = \{F \mid F_{[k-1]} < F < F_{[k]}\}$, then F_k^* must be the unique global maximum. If $F_k^* \notin J_k$, then the optimum must be on some other segment, at a corner, or at one of the kinks. Given the Japanese housing tax system, the user cost of capital, income, and preferences, it is possible to compute the optimum choice. [For details, see Hausman (1979).]

Because of optimization and/or measurement errors, observed floor space F^i for *i*-th household is given by,

$$F^i = F^{*i} + \varepsilon_F^i \qquad (11)$$

where ε_F^i is a stochastic term distributed normally with mean 0 and variance σ_F^2 and the superscript indexes the households. Given a household's budget set and preferences, it is possible to compute the global optimum F^* as described above. The likelihood function of this model is,

$$L = \prod_{i=1}^{N} \frac{1}{\sigma_F} \phi\left(\frac{F^i - F^{*i}}{\sigma_F}\right) \qquad (12)$$

where $\phi(\cdot)$ denotes the standard normal p.d.f.

If the floor space demand function given by (9) is to be consistent with the hypothesis of utility maximization, it must satisfy the condition

$$\frac{\partial F}{\partial UC(I)}\bigg|_U = \frac{\partial F}{\partial UC(I)} + F\frac{\partial F}{\partial Y} = a_1 + bF < 0 \qquad (13)$$

We maximize the log-likelihood function subject to (13). The maximum of the log-likelihood function is numerically estimated with the Berndt-Hall-Hall-Hausman method in TSP[3]. We used several starting values for the maximum likelihood estimation to assure a global optimum.

We present in Table 2 the estimation results when the floor demand function was estimated using a linear budget constraint and when the kinked budget constraint is controlled for in the manner described in this section. The former approach estimated the "marginal" floor demand function directly, that is, the demand functions that describe choice within segments by applying OLS. This "marginal" demand function shows the amount the individual would demand if the individual were to face a completely linear constraint with slope and intercept at that segment[4].

All explanatory variables are significantly different from zero with the expected signs. For instance, floor demand increases with the number of

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[3] Time Series Processor, Version 4.4 (TSP International).

[4] See Moffitt (1990, pp. 129-131) for details.

household members. Price elasticity is –0.22 and income elasticity is 0.17 under the kinked budget constraint model. These elasticities are computed on a household basis and have the expected sign although they apply only to points lying strictly on the interior of the segments.

Table 2 Parameter Estimates of Floor Space Demand Model

	Expected Sign	(Linear Budget Constraints)	(Kinked Budget Constraints)
Constant		25.100**	25.110**
		(2.810)	(2.820)
Age of head	?	1.040**	1.043**
		(6.300)	(6.330)
Price	-	-4829.600**	-4997.100**
		(-5.080)	(-4.980)
Income	+	1.731**	1.756**
		(2.900)	(2.940)
Household member	+	7.241**	7.219**
		(5.540)	(5.560)
σ_F		31.480	31.300**
			(28.400)
ln*L*		-1986.400	-1959.200
Price elasticity		-0.210	-0.220
Income elasticity		0.160	0.170

** Significant at the 1% level.
Note : Numbers in parentheses are asymptotic t value.

There are several important differences when we compare the kinked budget constraint model with the linear budget constraint model in Table 2. The price elasticity under the kinked budget constraint model equals –0.22, as compared to an elasticity of –0.21 in the linear model. Though this difference is not large, it is consistent with our prior expectation that consideration for the kink explicitly should increase the estimated price elasticity. There is a 11% reduction in the standard error on the price elasticity when the kink is explicitly considered. The income elasticity under the kinked budget constraint equals 0.17, up from 0.16 under the linear budget constraint (though the difference is not statistically significant). There is a 10% reduction in the standard error on the income elasticity under the kinked budget constraint.

It is also expected that the coefficient on the household member would be biased under the linear budget constraint model, because this variable reflects at least some of the size effects for home owners. That is to say, as the family size increases, the floor demand increases and vice versa. Thus the coefficient on the household member under the kinked budget constraint model is reduced (although this change is not statistically different from the linear budget constraint model).

Policy Simulations

In this section, we attempt to assess the impact on housing decisions of a modification of the Japanese differential property tax system and assess the efficiency effects resulting from this change. That is, we calculate the changes in floor space demand and compute the current excess burden when spaced-linked property taxation for newly built houses is abolished and the same usual property tax rate is imposed on all kinds of houses irrespective of the size of their floor spaces.

Simulation was conducted under the kinked budget constraint model and the linear budget constraint model. Change in floor space under the kinked budget constraint model was calculated as follows. First, desired floor space demand F^{*i} for i-th household under the present differential tax system was computed using (9) based on the search algorithm described in section 4 by putting the estimated parameter values in Table 2 into (9). Next, desired floor space demand for each household after abolishing space-linked property tax system was calculated by assuming the same property tax rate for all sizes of houses and then the difference between desired floor space after the revision and under the current system was computed. Finally the ratio between this difference and the desired floor space under the current differential tax system was computed.

Clearly, abolishing spaced-linked property taxation for newly built houses increases the floor space demand under both models, though the difference is not large. Households distort their floor consumption by underconsuming quantity of floor space under the current Japanese differential property tax treatment.

With this result, we now compute the Dead-Weight Loss of the Japanese housing tax system under the kinked budget constraint model using Equivalent Variation (EV). DWL is defined as the difference between EV and the amount of subsidies paid under the present differential property tax system, where EV is defined as the maximum lump sum the individual would be willing to be paid instead of subsidies on floor space. We calculate the amount of subsidies at the individual's optimum choice level under the actual tax system. In our model, corresponding to the linear desired floor demand function (9), the direct utility function is

$$U(C,F)=\exp\left\{-\left(1-\frac{b(C+A)}{F+b}\right)\right\}\cdot\left(\frac{F+b}{b}\right) \tag{14}$$

where $A=\frac{Z}{b}+\frac{a_1}{(b)^2}$ and $b=\frac{a_1}{b}$ and $Z=a_0+a_3D$ [5], and the indirect utility function and the expenditure function used are as follows:

$$V(P_F,Y)=\exp(-bP_F)\left\{Y+\left(\frac{a_1}{b}\right)P_F+\left(\frac{a_1}{b^2}\right)+\left(\frac{Z}{b}\right)\right\} \tag{15}$$

$$E(V,P_F)=V\times\exp(bP_F)-\left(\frac{a_1}{b}\right)P_F-\left(\frac{a_1}{b^2}\right)-\left(\frac{Z}{b}\right) \tag{16}$$

where P_F is the virtual price of the floor space. For each i-th household, desired floor space demand under the present system F^{*i} and corresponding desired consumption C^{*i} were determined using (1)(2)(9) based on the parameter values in Table 2. Then (14)(15)(16) were used to compute EV[6].

The excess burden of the floor space demand is 3,000 yen in the linear budget constraint model[7]. But the linear budget constraint model does not capture the true effect. The true excess burden of the floor space demand is 25,000 yen per household at 1993 prices and the amount of subsidies paid under the present differential property tax system is 13,000 yen per household at 1993 prices based on the kinked budget constraint model. The true excess burden of the floor space demand is approximately 78,035 million yen for all owner-occupied households at 1993 prices.

Conclusion

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[5] See Blomquist (1983) and Hausman (1980) for details.

[6] See Hausman (1981, 1984), van Soest et al. (1990) for details.

[7] The DWL under the linear budget constraint model was calculated based on the following formula:

$DWL=0.5\times\left\{(P_i-P_i^{'})/P_i\right\}^2\times e^{*}_{iP_i}\times P_i\times Q_i$ where $e^{*}_{i\,P_i}$ is the expected compensated price elasticity of demand for the i-th good, P_i is its price before changing the system, Q_i is the quantity demanded and $P_i^{'}$ is its price after changing the system.

In this paper, we present a microeconomic model of Japanese housing demand focusing on the nonlinear and nonconvex budget constraints peculiar to the Japanese housing tax system. We estimate the structural form using the maximum likelihood estimation for floor space demand. We find that the price and income elasticities are –0.22 and 0.17.

Using the result from the MLE, we try to predict how the floor space decisions of home purchasers would change if space-linked property taxation for newly built houses are abolished. Under the current system, households distort their housing consumption by underconsuming quantity of floor space and paying an excess tax burden of 25,000 yen per household at 1993 prices. It is approximately 78,035 million yen for all owner-occupied households at 1993 prices.

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