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Housing Demand in Tokyo

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Housing policy formulation should be informed by a careful understanding of the behaviour of the housing market, as reflected by housing demand. Such basic information is important, not only for improved project design but also for the development of better sector-wide policies. Housing is a complex outcome of cultural, economic and regulatory environment. Consistent estimates of price and income elasticity of housing demand are prerequisites for effective policy design. Results, from earlier studies on Japanese housing markets, are inconclusive and the estimates of price and income elasticity of housing demand vary over a wide range. It may be argued that measuring the volume of housing services as housing expenditure, as is done in previous research, essentially ignores the heterogeneity, and for large number of policy purposes like impact of tax on tenure choice, choice between owning and renting etc., the distribution of housing consumption into qualitatively different categories is of more interest than an aggregate qualitative measure of housing expenditure alone. This paper analyzes the demand for housing in Tokyo using a discrete choice model. Three dimensions of choice, tenure, dwelling size (as number of rooms) and structure type (as type of unit) determine demand for housing which are modeled simultaneously. The income elasticity of market share of ownership house is positive and ranges between 0.16 to 0.34. However, income elasticity for rental houses is negative ranging between -0.17 to -0.57. The own price elasticities vary over a large range from -0.03 to -5.1 with smaller in magnitude for ownership houses and larger for rental houses.

Keywords

Housing demand; Discrete choice model; Nested Multinomial Logit Model.

Introduction

Housing is a basic necessity everywhere in the world. As such, housing can be thought of as the most universal property type, demand for which is directly related to population demographics and to micro- and macro-economic factors like income growth and government policies. The demographics and the culture-based household characteristics are all critical determinants of the aggregate demand for housing, while other factors – wealth, age distribution, affordability etc. – tend to determine the types of housing most in demand. State of housing is a complex outcome of government policies, affordability and systems of provision of housing. Many countries today are trying to take corrective measures to enhance efficiency of the housing market operations. For effective policy formulation it is essential to understand the underlying demand for housing i.e. How much of housing do people want? And, what kind of housing do households would be able to afford?

This paper tries to analyze these questions for Tokyo (Japan). Tokyo Metropolitan Region (TMR) is one of the most populated metropolitan cities in the world with a population of around 33 million in 1994 (around 25% of Japan). The economic and geographical importance of Tokyo in the world has bestowed the status of being one of the most expensive real estate in the world. In a globalizing world, an analysis of housing demand in Tokyo is of interest to both domestic and the international community. Housing demand is a subject of research for many papers. Most papers relate to American or European housing markets. There is, however, paucity of research on housing markets in Japan, which is accessible to the international community. Japan has arguably one of the good household level data set on housing. Five papers to our knowledge have been written on housing demand for Japan [1] which differ in the methodologies, geographical coverage, data sources and hence the results (Tiwari and Hasegawa, 1999; Moriizumi, 1993; Horioka, 1988; Moriizumi and Takagi, 1983; Yamada et al., 1976). These studies attempt to estimate income and price elasticity of housing demand besides various factors that determine housing demand. However, the results from these studies vary so much that there is a need for another study with latest data and methodology. This paper adopts a discrete choice model, which earlier papers have not utilized. Housing or, more precise, the service

[1] Here we review only those papers, which are published in Journals that communicate in English. Author of the present paper is unable to review Japanese literature due to the language inability.

stream from a housing unit, is a heterogeneous commodity. Some dimensions such as size or age of structure, are measured on a continuous scale. Others, such as tenure or type of structure are discrete properties. Earlier studies measured the volume of housing services as housing expenditure essentially ignores the heterogeneity, and for large policy purposes, the distribution of housing consumption into qualitatively different categories is of more interest than an aggregate qualitative measure of housing alone.

The main contribution of the present paper is the estimation of housing demand using a discrete choice framework for Tokyo. The discrete choice model that is used in this paper is nested multinomial logit model (NMNL). Housing demand is a function of price and various household specific variables like income, household size and age pattern of household head. The prime focus of this paper is to estimate demand for housing in Tokyo prefecture comprising of 23 wards. Rest of the paper is structured as follows: Section 2 is an overview presenting the specific features of housing market in Japan. Section 3 briefly presents statistical overview of the Tokyo housing market and housing characteristics based on the data. Section 4 reviews previous studies. Section 5 briefly presents the model. Section 6 constructs various variables used in estimation of demand function. Section 7 presents results of demand estimation and section 8 concludes.

Features of Housing Market in Japan

There are four major features that characterize Japanese housing markets and distinguish it from housing markets internationally. The first and the foremost is the widely accepted view that Japanese houses are small and extremely expensive. Kanemoto (1997) in his paper discusses this issue at length and compares size and price of Japanese houses with European and American housing markets. He concludes that for overall Japan probably the size is not markedly different from international housing markets but houses in Tokyo are indeed small. Average ownership house is Tokyo has an area of around 70 square meter and the average size of a rental house is 38 square meter. In contrast the average floor size of an ownership house in UK is 75 square meter and a rental house is 70 square meter (Kanemoto, 1997). The different between ownership and rental housing in Japan are substantial. Owner occupied housing and rental houses are not close substitutes because the two categories are very different in the number of rooms per home and in the floor area (Tachibanaki, 1994). The differences in the size have consequence for the household size as well. Single-family households or married couples without children tend to live in rental houses with a smaller number of rooms

when they are young while older married households with children, and parents in some cases (called a joint family), tend to live in owner-occupied houses which are bigger in size. Getting married and having children are important determinants of switch from rental to ownership houses in Japan. The supply of good rental houses is also constrained by the Land Lease Law[2] and Building Lease Law. These provisions have rendered rental housing defunct and the supply of the rental houses is an outcome of these laws. There are many other constraints that act in the way of rental housing supply and this we will discuss later.

Another feature of housing markets in Japan is the role that bequest plays in housing decisions. Bequest is an important motive in Japanese household and housing is one of the best forms of bequeathed wealth. Tachibanaki (1994) presents an interesting data which indicates that in Tokyo, of the total owner occupied houses, 45% were bequest or gifts. It may be emphasized here that the data used in his study are from 1989 survey on Financial Asset Choices of Households conducted by the Ministry of Post and Telecommunication. Japan is an aging society and the average number of children per family has reduced significantly. Taking aging factor into account, the share of housing as bequest would be much higher. Besides this owner houses have considerable advantage in inheritance taxes. Up to 200 square meter, the residential land is permitted automatic deduction (Kanemoto, 1997). The degree of desire to bequeath land and house increases as income level increases (Tachibanaki, 1994). This means that as income rises the desire to own a house becomes more and more strong. Tachibanaki (1994) shows that more than 50% of households in Japan in the age group of 35-39 have their own houses. More than 70% of households above 40 years of age have their own house.

[2] The Land lease law was strengthened during the World War II as social legislation with the aim of strengthening the right of the lessee by bending the principle of freedom of contract provided in the Civil Code. During the war, a large number of families were faced with the danger of being evicted from their leased land or houses while the head of the family was called for active military duty. With the view of protecting the right of lessee and tenant, the government strengthened these laws. Under the strengthened provisions, a land lease contract is automatically renewed when the term expires, unless the landlord makes a formal objection without delay. The new contract is assumed to continue for the period of thirty years. The objection of the landlord is admitted only if he can show a personal need for the use of land or other "just causes," which are interpreted very strictly in the court. There are provisions for revision of rents but lessee or tenant can again approach court to determine "fair and reasonable rent." Until court decides on the rent, tenant can continue to use the land by depositing an amount with the court that he deems justified for the rent of land. Landlords have very little negotiating leverage. The building lease law is similar in nature and exists for buildings (Noguchi, 1994).

The third feature of the housing markets in Japan is that the most desired type of housing is a moderately spacious single-family house with a garden. However, this notion is shifting primarily for affordability reasons (Yamada, 1999). A survey conducted by Nihon Keizai Shinbunsha (1988), right after the period of very high prices, indicates that 70% of renters and 60% of owners in Tokyo have given up their desire for such a house because of high price and have switched their desire towards apartments or condominiums. Affordability has been an important parameter. The White Paper on Households' Living Conditions (Kokumin Seikatsu Hakusho), published by former Economic Planning Agency, calculated the degree of ability[3] to buy houses. The survey indicates that in Tokyo the ability to buy a single family house is 39% and apartment of condominium is 62% for a house of 167 square meter land area and 89 square meter floor area of single family house and 78 square meter floor area of apartments.

The fourth feature of housing markets in Japan is the subsidy in housing finance and this has implications for the type of houses that are constructed. Housing Loan Corporation (HLC) provides low interest rate loans to households for either construction or purchase of new houses. The interest rates are 2 to 3% lower than the market rate. There are, though, ceiling on the maximum obtainable loan and the HLC loan has to be supplemented by the loans from commercial banks. Moreover, HLC requires that certain conditions regarding floor space, price of house and income of borrower were met. The interest rates changes depending on the floor area. Seko (1993) found that the budget constraint in the demand function has jumps. For example, the floor spaces of many houses in Japan are around 120 square meters because for houses more than this size, HLC interest rates are higher.

Transaction cost and government policies are some other features that characterize housing markets in Japan. Imperfections in housing market have made rental tenure as less favoured. The transaction and search cost of rental housing is very high. Changing a rental house is very expensive. This is reflected in the fact that the availability of large size rental housing is limited.

Ito (1994) shows in his paper that the bequest tax has caused distortion in the housing market. The Japanese bequeathed asset consists mostly of real estate. In fact, Japanese elderly, who plan to bequeath some assets, have strong incentive (i) to hold on to their principal residence, no matter, how mismatched for their requirements, and (ii) to purchase real estate with high

[3] Ability = Attainable housing loan and financial assets*100/ Cost of house

leverage. The later strategy is tax saving strategy as real estate is assessed at much less than market value and liability is deducted from the estate in full (Kanemoto, 1997). Housing loans for owner-occupied housing have only a partial tax benefit in Japan (in the form of tax credit). This in combination with large down-payment burden, works to delay the purchase of house in the life cycle (Ito, 1994). In contrast, landlords of rental housing property, especially with more than ten units, enjoy various tax benefits. As mentioned earlier that Land Lease Law and Building Lease Law in Japan protects tenants so much that no landlord would want to put high quality housing on the rental market. The result is that as household size grows, it is necessary to purchase a house instead of relocating to a large rental house, which is nonexistent.

The overview of housing market above indicates that (i) the housing market in Japan is skewed in favour of ownership houses. Bequest motives and tax advantages associated with it make this form of tenure favourable. (ii) Large rental houses are non existent. This is a consequence of Laws that govern land and building leasing in Japan. Tenancy protection is very strong and does not leave much leverage for owners. (iii) Housing finance system has also shaped the quality and size of houses in Japan. (iv) Affordability is a major driving element in the choice of houses. (v) Tax incentive has not played key role in the tenure choice in Japan.

Statistical Overview of Tokyo Housing Market

This paper uses the housing data from 1993 Housing Survey of Japan, Statistics Bureau, Management and Coordination Agency, Government of Japan (1993). The sample contains 245614 households (115928 households in rental and 129686 households in ownership houses) living in Tokyo prefecture. Tokyo prefecture consists of 23 wards with Chiyoda-ku as the Central Business District (CBD).

The mean and standard deviation of various house characteristics for owners and tenants are given in table 1. Our database does not have information on the value of ownership houses. The data does not have any other information like home loan repayments etc. which may help us in estimating instruments for imputed rent of ownership houses. We have used hedonic price function estimated for rental houses to impute rental value for ownership house. Imputed rental values for ownership houses may be viewed as rents which households pay to them. In a perfect housing market, the imputed rent of house should be equal to amortized house value at the rate of depreciation of house. The monthly-imputed average value of rent for ownership house in Tokyo is 164653.5 Yen and the average rent for rental houses is 81738.5 Yen.

Table 1: Mean and Standard Deviation of Housing Characteristics for Houses in Tokyo

Variable	Tenants		Owners	
	Mean	Std-Dev.	Mean	Std-Dev.
Distance from CBD (Km)	15.75	11.12	17.35	12.66
House leading to public sewerage (if yes)	95%		92%	
Distance of hospital (meter)	257.39	221.52	287.84	246.84
Distance of park (meter)	455.98	310.78	437.8	311.7
Distance of public hall (meter)	448.23	268.59	455.55	279.7
Distance from 6 m wide road (meter)	77.28	96.16	78.5	98.7
Houses in good condition (if yes)	91%		95%	
Houses with elevator (if yes)	14%		15%	
House age (years)	14.88		18.12	11.59
Floor area (m2)	32.63	22.85	96.4	46.3
Houses with toilet (if yes)	98%		100%	
Houses with Water Closet (if yes)	95%		97%	
Number of toilets	1.05		1.39	
Houses with bath (if yes)	82%		97%	
Houses with Air Conditioner (if yes)	62%		91%	
Houses with Air Conditioner in individual rooms (if yes)	58%		85%	
House with central Air Conditioner (if yes)	5.3%		8.59%	
Houses with carport (if yes)	2.5%		16%	
Duration of sunshine (hours per day)	3.66	1.49	4.06	1.31
Household size (number)	1.85	1.16	3.17	1.43
Number of Rooms	2.21	1.13	5.04	1.73
Monthly Rent (Yen)	81738.5	62025.9	164653.5	85996.7
Number of observations	115928		129686	

Household housing demand is a function of various household characteristics and income distribution. Annual income distribution of households in Tokyo indicates that the lower 40% of households have annual income less than 4 million Yen.37% of households have annual income

between 4 to 7 million Yen. 23% of households have income of more than 7 million Yen per year.

Occupation wise, 0.1% of tenants are farmers, 10.4% are self employed, 62.8% are employed in office or firms, 5% are public servant, 4.1% are employed part-time, 5.8% are students and rest are unemployed.

The most preferred tenure in Japan is home-ownership. Every Japanese household has a dream of owning one's own house. Intergenerational transfers relating to housing are very common. For example, most households receive land/housing as bequests of gifts and many households receive financial assistance from their parents to facilitate home purchase

Review of Past Studies

Housing demand is a widely studied subject. Numerous literature exists that analyzes housing demand using different methodologies and for different geographical context (see of a review Muth and Goodman, 1989; Tiwari, 1996). In this paper, we review studies related to Japanese housing markets since the focus of present paper is on Japanese housing markets. While reviewing we will briefly mention the methodological difference and differences in results. Most of the methodologies used in Japanese papers are similar to papers on other housing markets and by reviewing methodologies used in these paper we *de facto* review huge literature on international housing markets. There are five studies which estimate housing demand in Japan (Tiwari and Hasegawa, 2000; Moriizumi, 1993; Horioka 1988; Moriizumi and Takagi, 1983 and Yamada et al., 1976), using household level data. Later two studies use a single equation model of housing demand. These studies estimate housing demand separately for tenants and owners. The literature on housing demand has convincingly indicated that households make their choice for tenure and housing consumption simultaneously. The studies by Tiwari et al., Moriizumi (1993) and Horioka recognize the simultaneity of housing demand and tenure choice and their studies explicitly model the joint decision of housing demand and tenure following Lee and Trost (1978) methodology.

Another point of difference among these studies is related to the measure of income. Yamada et al. (1976) uses pretax current income. Moriizumi et al. (1983) estimates an instrument for permanent income by regressing current income on life cycle variables. The fitted regression value is the permanent income used in their model and the residual is transitory income. Horioka (1988) estimates an equation similar to Moriizumi et al. and takes weighed

average of current income and fitted value of regression as his instrument. To this, he adds the tax adjusted imputed value of rent for owner households to arrive at permanent income. Moriizumi (1993) uses a similar methodology for her permanent income measure. While they made adjustments for taxes, they did not deal with the subsequent problem of correlated regressor and error introduced by the procedure. The bias introduced could be considerable. Tiwari et al. estimate permanent income similar to Moriizumi (1983).

Thirdly, the measure of price variable differs in these studies. Yamada et al. employ two household specific price indices (namely land rent divided by lot size and structural rent divided by floorspace), but such measures fail to control for differences in quality and other housing characteristics. Moriizumi and Takagi do not have a price variable in their model. Horioka (1988) uses price variable based on "user cost of capital" approach. The price variable so defined is product of unit price of ownership house and cost of capital. For rental housing they have used data on interregional differences in rent levels obtained from 1982 Zenkoku Bukka Tokei Chosa (National Survey of Prices) (Prime Minister's Office, Statistics Bureau (1984, Table 2 pp.10-73)). Moriizumi (1993) uses a price variable similar to Horioka. Tiwari et al. estimate a Box-Cox hedonic function of rental values and estimate price indices for a standardized bundle of housing commodity at different locations in Tokyo. Their model uses similar price indices for owner and rental houses.

The demand elasticity estimates of Moriizumi et al. and Yamada et al. indicate inelastic housing demand with income and prices. Horioka's analysis indicates that the income elasticity of demand for housing in Japan in 1.4 (highly elastic) and price elasticity of demand is –0.8 (inelastic). Elasticity estimates from Moriizumi (1993) analysis indicate an income elasticity of 0.11 for owner households and -0.05 for tenants and price elasticity of -0.13 for owners and -0.67 for tenants. Tiwari et al. indicates that the elasticities of demand for rental housing is inelastic with respect to permanent income and price at 0.26 and –0.33 and for owner houses are inelastic with income as well as prices at 0.37 and –0.38.

These five studies estimate elasticities, which vary over a wide range. The most fundamental difference is in choice of variable and geographical coverage. The income elasticity of housing demand is inelastic within a region but elastic across the regions (Mayo, Malpezzi and Gross, 1985). Horioka's (1988) study-sample includes households from all over the Japan while other studies are for Tokyo. This is the reason why Horioka's income elasticity estimates are elastic while other two papers report income inelastic housing demand. The omission of price variable definitely biases income elasticity downwards (Polinsky, 1977) as has happened in Moriizumi et al

(1983). The price variables included in other two papers, is also not representative of price of a standard commodity in various locations. Taking one price over a metropolitan region and a city (as in Horioka, 1988 and Moriizumi, 1993) leads to aggregation bias and biases the elasticity estimates upwards. Price per unit area is not the right measure of price (in Yamada et al., 1976) as it ignores other characteristics of housing.

Secondly these results are different due to measure of income variable. Literature on housing demand convincingly concludes that households make housing decisions based on their permanent income (Mayo, 1981). Permanent income elasticities are higher than current income elasticities. Moriizumi et al in their paper use permanent income, which is the fitted value of current income on characteristics, related to human capital. However, the permanent income elasticity of demand estimated in their paper is less than current income elasticity of demand. Yamada et al. (1976) uses current income. Horioka (1988) and Moriizumi (1993) estimates permanent income as sum of imputed rent for owners and weighted average of current income and instrument obtained as fitted value of regression of current income on human capital (following the methodology suggested by King and Dicks-Mireaux, 1982). Their studies estimate tax and social security contribution of each family and subtract it from the permanent income estimates. The problem here is that they do not take care of the problem of correlated regressor and error introduced by this procedure.

Two variables, which need discussion, are the price and income variables. We estimate hedonic price function to derive price variable for our model, which is discussed below. The measure of income that is employed is permanent income because use of current income imparts well-known downward bias to the income elasticity estimates.

Earlier estimates of income and price elasticities of housing demand based on above five studies for Japan are inconclusive as policy parameters. We argue that it is not meaningful to estimate pure renter model or a pure owner model because, for example, in a pure owner model we ignore the possibility that the household could have rented shelter but in fact chose not to do so. Housing consumption decisions include the choice of tenure, size of house and type of structure, as described by the eight alternatives (appendix 1).

Household chooses one of the above eight alternatives, based on his preferences, which can be represented in a hierarchical tree structure (see Figure 1). Households associate an index of desirability to each of these alternatives, which comprises all advantages and disadvantages for a given consumer into one scalar unit corresponding to the indirect utility function in

neoclassical consumer theory. Uncertainty about quality and irrational valuation introduces a stochastic component into this index. Like the hypothesis of utility maximization under budget constraint the assumption is that each household will choose the alternative with the highest index of desirability. The following section provides a brief exposition of our econometric methodology, the estimation of hierarchical choice models.

Housing Choice Model

The simplest and most convenient functional form for a discrete choice probability of alternative i is the standard multinomial logit form (McFadden, 1973).

$$P(i \mid C, z, b) = \frac{\exp(Z_i b)}{\sum_{j=1,\ldots,n} \exp(Z_j b)} \qquad (1)$$

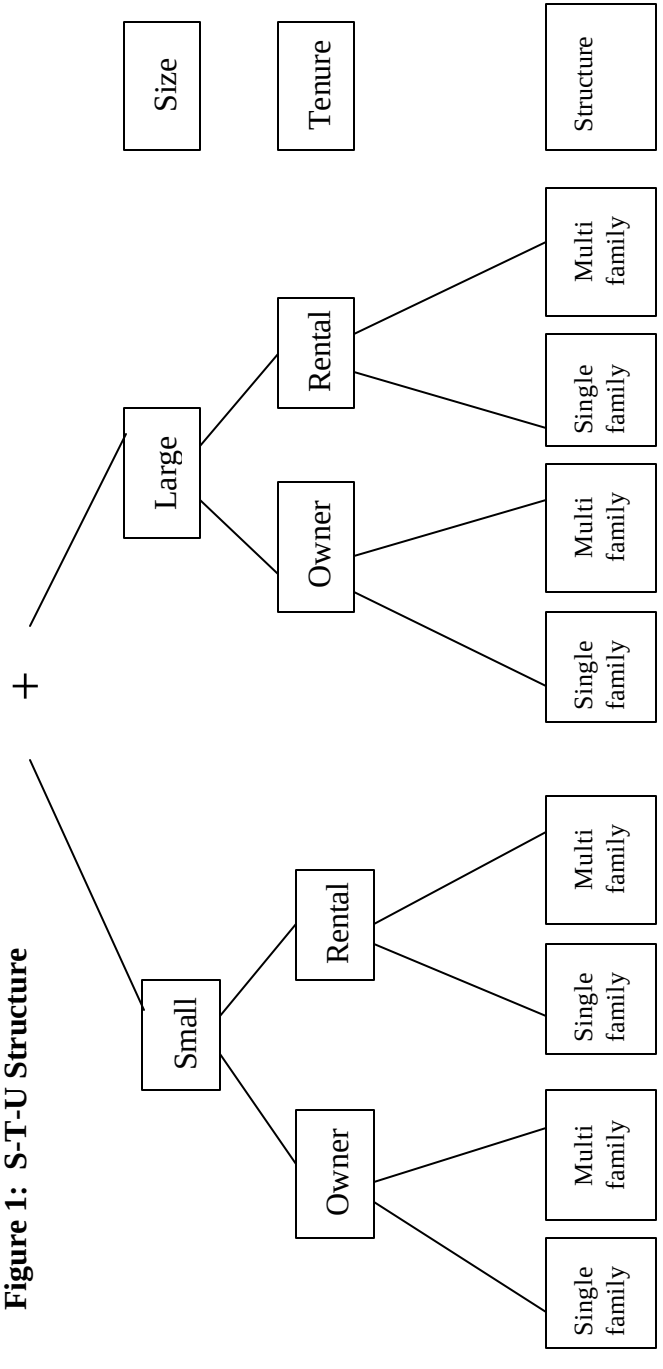
where C = {1,…,n} denotes the set of n discrete housing choice, Z_i *a* vector of K attributes specific to choice i, and ↕ a vector of corresponding taste parameters.[4]

Multinomial logit functions are easy to compute but they assume that the choice between any two alternatives is independent of the attributes and even the availability of any other alternative. This property is called Independence of Irrelevant Alternatives (IIA). It implies that the cross-elasticities of the probability shares must be equal (see, Boersch-Supan, 1988). A relatively easy and intuitive generalization of the MNL specification-the nested multinomial logit model (McFadden, 1981) - is based on hierarchy of grouping of alternatives into subsets of similar choices. It is useful to visualize these hierarchical choice models as defining a pattern of linkages among clusters of alternatives. Each node of the linkages corresponds to a choice among clusters of alternatives. In the simple MNL model, all the elemental alternatives are linked directly. In a hierarchical choice model, some of the linkages lead to clusters of alternatives rather than to a single alternative. The choice within a cluster and the choices between the clusters within each nest are described by a conditional logit choice probability and conform to the IIA assumption. Our example of housing choice is represented

[4] The choice probability can be derived from utility maximization by defining $\ell_{\square}^{*}=z_{\square}$ ↕ + $\square_{\square}$as the stochastic utility of housing choice I where $\square_{\square}$ follows a type I extreme value distribution, see McFadden (1973).

by the tree structure shown in Figure 1. It may be pointed out here that a variety of tree structures are possible depending on positioning of tenure choice, unit size and type of unit in the hierarchy. With three levels of choices, six tree structures are possible. We have tried these six trees besides the simple multinomial logit model. To keep the discussion simple and avoid too much of statistical details, we show only the best performing tree in Figure 1.

Figure 1: S-T-U Structure



Mathematically, the choice probability of alternative ij…k in the NMNL model is

$$P(ij...mk) = P(i) * P(j \mid i) * ... * P(k \mid m... ji) \quad (2)$$

The conditional probabilities in each cluster have the form of MNL choice probabilities

$$P(m \mid n... ji) = \frac{\exp\{I(m,n,..., j,i) * s(m,n,..., j,i) / s(n,..., j,i)\}}{\sum_{m'} \exp\{I(m',n,..., j,i) * s(m',n,..., j,i) / s(n,..., j,i)\}} \quad (3)$$

where the "inclusive values" I(m,…,j,i) are recursively defined by

$$I(k,\ldots,j,i) = Z_k b \ / s\,(k,\ldots,j,i) \quad (4)$$

$$I(n,..., j,i) = \log \sum_{m'} \exp\{I(m', n,..., j,i) * s(m', n,..., j,i) / s(n,..., j,i)\} \quad (5)$$

and weighted by "similarity coefficients" s(m,…,j,i). These similarity coefficients refer to their respective clusters and characterize the degree of substitutability among the alternatives in the cluster. Setting all the similarity coefficients to unity restricts NMNL to MNL specification. Hence the difference of the similarity coefficients from unity is a measure of the importance of similarities and dissimilarities among choices. Estimation of the NMNL can be done by full information maximum likelihood (FIML) technique.

Specifications of Demand Equations

In this section we will discuss the explanatory variables that determine the housing demand.

HEDON = Hedonic index as a measure of user cost
INCOME = Permanent income before taxes
AGE = Age of household head
HSIZE = Household size

Housing Price

The measure of house price is the user cost of housing capital. Since we do not have information about house price for ownership houses, we estimate imputed rent for owners, based on hedonic indexes computed on renter sample, as the user cost. The first step is to estimate a hedonic function from the renter sub-sample for Tokyo. The methodology adopted is discussed below.

Let $Z = Z_i = (Z_1,...,Z_n)\ \forall i = 1,\ldots,n$ be a vector of housing characteristics and P(Z) be a hedonic price function defined by some market clearing conditions. The household decision is characterized by the utility function

$$U = U(X,Z), \tag{6}$$

where X is a composite commodity other than housing whose price is unity. Households maximize utility subject to their budget constraint

$$Y = P(Z)Z + X. \tag{7}$$

The first order condition yields,

$$P_i = \frac{U(Z_i)}{U(X)}, \tag{8}$$

where P_i is the implicit prices that households have assigned to characteristic i.
Estimation of these implicit prices can be done by regressing market values of house prices P, measured as rents, as a function of various housing attributes.
Thus

$$P(Z) = f(Z_i,.....,Z_n). \tag{9}$$

Since we do not have any prior notions about the shape of the hedonic function, we estimate alternative forms of Box-Cox transformations. We estimate the general Box-Cox Functional Form given below

$$P(Z)^{(t)} = b_0 + \sum_{i=1}^{k} b_i Z_i^{\,l_i} + 0.5\sum_i \sum_j g_{ij} Z_i^{\,l_i} Z_j^{\,l_j} \tag{10}$$

where

$$P(Z)^{(t)} = [(P(Z))^{(t)} - 1)]/t \quad (11)$$

and

$$Z^{(l_i)} = (Z^{(l_i)} - 1)/\, l_i \quad (12)$$

where the b 's are the market –determined parameters, l is a parameter used to transform housing characteristics to do Box-Cox analysis, and t is transformation parameter for rent (P). Nonlinear methods are used to find optimal values of transformation parameters. The first derivative of rents with respect to housing characteristics in the above equation, are the implicit prices. The hedonic function is used to estimate price indices as well as imputed rent for owner houses.

We do not report parameter estimates of various variables of the hedonic function, as they are of less interest than the implicit prices i.e. the marginal price of various variables that determine the house price. In table 2, we present these implicit prices. It may be pointed out here that the point estimates of various transformation coefficients are significant and very different from Zero (A value of zero indicates that the functional form is Log-linear, a most commonly used functional form in the housing literature). The coefficients of all the attributes of housing are significant.

Table 2: Implicit Prices for Housing Characteristics

Variables	Japanese Yen
Distance from CBD(Km)	-1008.5 (0.7373)
Area of house (Sqm)	608.31 (0.7355)
Duration of sunlight (hr)	660.09 (0.2576)
Number of rooms	7172.2 (0.5348)
Age of House (years)	-724.42 (0.8896)
Dummy for sewer (1=yes; 0=No)	1684.3
Dummy for Good Condition (1=yes; 0=No)	5098.5
Dummy for Elevator (1=yes; 0=No)	19621
Dummy for toilet (1=yes; 0=No)	16980
Dummy for Bath (1=yes; 0=No)	26476
Dummy for WC (1=yes; 0=No)	11517
Dummy for second toilet (1=yes; 0=No)	3568.9
Dummy for Aircon (1=yes; 0=No)	4704.4
Dummy for carport (1=yes; 0=No)	11897
Transformation parameter for dependent variable	0.20

Variables	Japanese Yen
R-squared	0.6277

Note: In Box-Cox quadratic model figures in bracket represent the transformation coefficient for the
variable. The transformation coefficients for dummy variables are 1.
All coefficients are significant at 5%.
*Insignificant

The implicit prices are very interesting as they indicate the market price of each additional unit of housing characteristic. Distance has a negative coefficient. A house 1 Km away from CBD of Chiyoda-ku would reduce the rent by 1008 yen, ceteris paribus. Area is an important determinant of rent. An increase in house area by 1 square meter increases the rent by 608 yen. The dummies for all amenities like toilet, bath and air-conditioner have positive significant coefficients. House age variable indicates that new houses are more expensive than old ones. Sunshine has positive coefficient, though this variable is not significant.

Since we do not have information about house values for ownership houses, we were unable to compute price indices for ownership houses separately. Hedonic rent indexes are estimated from hedonic function of renter households and estimated at each dwelling. This yields an imputed rent also applicable to owner housing. It is well known in housing literature that out-of-pocket costs are perceived differently by tenants and owners but our measure uses same function. We, therefore, allow the general attractiveness of owning versus renting - the freedom of disposition, by letting the hedonic indexes interact with tenure choice. We obtain two hedonic prices:

HEDONO = imputed hedonic rent, if dwelling is owner occupied, and 0, otherwise
HEDONR = imputed hedonic rent, if dwelling is rented, and 0, otherwise.

In a choice among several alternatives, the attributes of all choices enter the decision process of the households. In econometric terms we have to specify the explanatory variables for all alternatives in the choice probabilities. However, only attributes of chosen alternatives are observed, not those of rejected alternatives. We impute the attributes of a hypothetical (an alternative not chosen) as the sample average of these attributes in the population.

Permanent Income

As discussed earlier the housing demand is a function of permanent income. Following the literature we estimate permanent income function in terms of human capital of households. We use a procedure similar to Moriizumi (1983). Table 3 presents estimated permanent income function.

Table 3: Permanent Income Function

Dependent variable: Log (Annual income)

Independent Variable	Coefficient	T-stat
Constant	14.011	
Age of household head (years)	0.009	125.44
Dummy for occupation as farmer (1-yes; 0-no)	0.598	16.7
Dummy for occupation as self employed (1-yes; 0-no)	0.876	222.8
Dummy for occupation as company employed (1-yes; 0-no)	0.979	357.2
Dummy for occupation as public servant (1-yes; 0-no)	1.212	236.7
Dummy for occupation as part-time (1-yes; 0-no)	0.131	23.8
R-squared	0.29	

The age has a positive coefficient as expected. The dummies for occupation indicate that public servants have the highest income followed by company employed and then by self employed, farmers and part-timers in that order.

In our model, income varies by household and is not alternative specific, it drops out as irrelevant for a pair wise comparison of alternatives. Therefore, we create an interaction of income with each alternative by multiplying it by a set of alternative specific dummy variables. Specifically, we exploit the symmetrical tree structures and let income interact with a dummy variable for each dimension of choice so that we obtain three income variables:

INCOME.RENT = INCOME, if household is tenant
= 0, if household is owner
INCOME.SFM = INCOME, if household lives in single family structure
= 0, if household lives in a multifamily structure
INCOME.14R = INCOME, if household lives in dwelling with 1-4 rooms
= 0, if household lives in a dwelling with 5 or more rooms.

Other variables

Age of the household head and household size are the two other variables included in the equation. Age takes account of the difference in the life-cycle

pattern of the housing consumption within each stratum. Household size measures the household response in relation to changes in household size.

Estimation of Demand Equations

We estimate seven alternative specifications of demand model. One of them is the multinomial logit model and six are various nested trees (derived from hierarchical positioning of tenure choice, unit size and unit type, one of them is shown in Figure 1). To economize on computation costs, all estimations are based on small sub-sample of 9600 households (nearly 4% of original data set) drawn randomly from the larger population and estimated by maximum likelihood procedure. The method proved extremely cost efficient without causing major losses in precision of the estimates.

Table 4 reports the estimation result for the best performing tree. To avoid unnecessary statistical detail we do not present results for all trees. The performance of trees is evaluated on the basis of various performance statistics like Likelihood value, correct prediction[5], McFadden R^2 and also dissimilarity coefficients. All the nested trees performed better than simple MNL. The estimated coefficients for the tree, which performed most satisfactorily, are presented in Table 4. The upper rows in table 4 report summary measures on fit.

The estimated coefficients in table 4 represent the taste parameters of the utility function underlying our demand functions. As discussed earlier, income, age and size interact with indicator variables for each of the three choice dimensions. The coefficients of income, age and size in each alternative can be calculated by adding up the three interactions. For example, the income effect in the alternative of large (five or more rooms) single-family rental house is composed of the income effect of renting and income effect of single family house. Note that in this example we eliminate the contribution of size choice because large dwellings are the reference or excluded case. The household size and household head age variables are significant.

Price Elasticity of Housing Demand

When the coefficients of table 4 are transformed into elasticity of choice

[5] Amemiya (1981) gives an extensive discussion of goodness of fit measures in discrete choice models.

probabilities with respect to income and housing price variables, the result is a convenient and intuitive sense of their magnitudes for comparison across strata. The elasticity measures the percentage changes in the market share of housing alternative i when the kth attribute of alternative j is changed by one percent. For example, it measures the percentage change in the market share of large single family rental housing when the rent of large apartments is increased by one percent. The NMNL model produces for

Table 4: Demand Equation

Estimates for the tree shown in Figure 1	
Performance statistics	
Likelihood	-8435
R-squared	0.58
Correctly predicted (%)	67.9
Estimation Coefficients	
Alternative specific variables	Coefficients (T-statistics)
HEDONR	-0.12 (82.6)
HEDONO	-0.005 (3.6)
Agent specific variables	
INCOME*RENT	-0.0001 (1.16)
INCOME*SFM	0.0004 (1.51)
INCOME*14R	-0.0012 (5.59)
SIZE*RENT	-0.09 (8.34)
SIZE*SFM	0.5 (17.5)
SIZE*14R	-0.28 (10.2)
AGE*RENT	-0.015 (18.6)
AGE*SFM	0.07 (31.4)
AGE*14R	-0.014 (7.4)
Alternative specific constants	
R-SF-14	-3.18 (13.03)
R-SF-5	-5.63 (32.78)
R-MF-14	3.60 (23.9)
R-MF-5	-0.42 (6.03)
O-SF-14	-7.52 (30.1)
O-SF-5	-3.83 (21.6)
O-MF-14	2.84 (19.2)
Dissimilarity parameters	
Bottom far left	1.78 (68.1)
Bottom left	3.64 (76.3)
Bottom far right	0.79 (9.6)
Bottom right	0.89 (7.6)
Top left	0.08 (249.9)
Top right	0.01 (979.7)

each variable an entire array of cross elasticity that describes the changes in the market share of each alternative in response to the changes of this variable in all other alternatives. For the pooled sample, the elasticity matrix for the hedonic rent variable is shown in table 5. All elasticties are evaluated at sample means. The housing alternatives are denoted by their indexes as discussed earlier. The hierarchy of the tree is reflected in the block structure of equal or unequal elasticities. The first row describes the reaction of the eight market shares to an increase in the out-of-pocket cost of small-rental-single family house by one percent. The S-T-U (size-tenure-unit type) structure forces this reaction to be equal across the two ownership houses (their market share increases by 0.34%) and to be equal across all large size houses (their market share increases by 0.03%). Each column lists the response of a given market share on a change in the price of each alternative.

The price elasticities indicate that if price of a rental housing increases the corresponding alternative's market share decreases and there is a switch to other alternatives and the most pronounced increase is in owner housing alternatives. For example, an increase in price of single family-rental-large size houses by one percent reduces its market share by 5.1%, reduces market share of single-family rental small size house by 4.7%. This increases the market share of both large (more than 4 rooms) and small (1 to 4 rooms) single family ownership houses. There is very little rise in the share of multi-family houses and most of the shift is from single family rental houses to single family ownership houses. Similarly, an increase in the price of a multi family-ownership house by one percent reduces the market share of this alternative but by a very small percentage. This result supports the view that the demand pattern is changing due to affordability parameters. Households constrained by their wealth do not change their demand for multi-family ownership houses much with increase in the price. Reason is obviously that the substitution within ownership tenure for multi family houses (i.e. to single family house) is unaffordable for a large segment of population. The own price elasticities vary over a large range between -0.03 to -5.1. The negative own price elasticity for rental housing indicates Japanese choice of ownership housing.

Income Elasticity of Housing Demand

The income elasticities are composed of the elasticities with respect to each of the three income choice-dimension interactions. The sum of three components gives a comprehensive income elasticity. These comprehensive elasticities describe the percentage change in the market share of each alternative when the household's permanent income if increased by one

percent and are shown in table 5. The income elasticities indicate that with increase in household income Japanese household would choose ownership houses. All income elasticities for owner houses are positive and for rental houses are negative. With rise in income there is definitely a switch towards ownership houses. The income elasticity of multi family ownership houses is higher than single family ownership houses. High land cost is a major factor, which constrains households from owning single family houses.

Table 5: Price and Income Elasticities of Market Share

Price Change	14-R-SF	14-R-MF	14-O-SF	14-O-MF	5-R-SF	5-R-MF	5-O-SF	5-O-MF
14-R-SF	-.67	-.14	.34	.34	.03	.03	.03	.03
14-R-MF	-1.4	-1.97	3.4	3.4	.27	.27	.27	.27
14-O-SF	.035	.035	-.08	-.07	.003	.003	.003	.003
14-O-MF	.043	.043	-.09	-.09	.003	.003	.003	.003
5-R-SF	.01	.01	.01	.01	-4.2	-3.9	.07	.01
5-R-MF	.01	.01	.01	.01	-4.7	-5.1	.02	.02
5-O-SF	.02	.02	.02	.02	6.7	6.7	-.3	-.22
5-O-MF	.003	.003	.003	.003	.94	.94	-.03	-.08
Income Change								
	-.57	-.21	.16	.33	-.56	-.17	.17	.34
Household Size Change								
	-13.96	-0.51	2.52	-2.69	-13.46	2.16	3.3	-1.61
Age of Household Head Change								
	-10.3	-1.78	3.76	0.02	-9.98	-0.29	3.39	0.6

Impact of Other Variables on Housing Demand

If the household size increases by 1%, the shift in housing choice is towards single family ownership houses. The share of single family rental houses decreases drastically by more than 13% for both large and small houses respectively. There is a slight increase in the market share of multi family rental houses as well but this may be viewed as income constrained household first move to large multi-family rental houses before accumulating enough wealth to move to single family ownership houses. Single family ownership houses are preferred by large families while multi family houses are preferred by nucleus families.

Another important variable that determines housing demand is age of household head. Table 5 indicates that if age of household head increases by 1%, the market share of single family and multi family ownership houses increases. The increase in the market share of single family ownership houses is larger than the multi family ownership houses.

Conclusion

Few studies have been conducted to estimate housing demand in Japan. These studies have estimated demand function where measure of demand is housing expenditure. The results are far from conclusive and the estimates of price and income elasticities vary over a wide range from elastic to inelastic. We argue that it is not meaningful to estimate pure renter model or a pure owner model because, for example, in a pure owner model we ignore the possibility that the household could have rented shelter but in fact chose not to do so. Measuring the volume of housing services as housing expenditure, as is done in previous research, essentially ignores this heterogeneity, and for large number of policy purposes like impact of tax on tenure choice, choice between owning and renting etc., the distribution of housing consumption into qualitatively different categories is of more interest than an aggregate qualitative measure of housing expenditure alone. We use a nested multinomial logit model (NMNL) as the basic analytical tool for our analysis. The microeconomic and econometric foundations of NMNL models encompass the elegant theory of housing economics of a utility maximizing household. NMNL models impose a hierarchical structure on the choice set that can be visualized in the form of a decision tree. Three dimensions of choice, tenure, dwelling size (as number of rooms) and structure type (as type of unit) generate these steps of clustering. This paper estimates the choice probabilities and demand elasticities of various housing alternatives for Tokyo using 1993 housing survey data for 23 wards.

The results of the demand analysis indicates that households choose ownership houses. As the income grows or the size of household increases, there is a requirement for bigger houses. Most of the rental houses in Tokyo are smaller in size. Since a large size rental house is not easily available, households move to ownership houses. The income elasticity of market share of ownership house is positive and ranges between 0.16 to 0.34. However, income elasticity for rental houses is negative ranging between -0.17 to -0.57.

Price is another important variable determining the choice of house. An increase in the price of rental houses reduces its demand by much larger proportion than the corresponding decline in demand for ownership houses with an increase in price of ownership houses. The own price elasticity varies over a large range from -0.03 to -5.1 with smaller in magnitude for ownership houses and larger for rental houses. Rental houses lack in quality as mentioned earlier. Households live in rental houses during their earlier stage of demographics. As household size and age increases, they move to ownership houses.

Housing in Tokyo is an outcome of various cultural, policy and demographic behaviour. Bequest motive of elderly in Japan is very high and real estate is major form of wealth transfer. An important finding is that when the price of large ownership houses increase, there is a switch towards large rental houses rather than other alternatives. This indicates that there is a market for large size rental houses in Tokyo. However, in Tokyo regulations have affected the outcomes in housing markets to a large extent. Laws like Land Lease Law or Building Lease Law, which protect tenants, have constrained the supply of quality rental housing. The consequence of such constraint is one of the causes of high price of ownership houses in Tokyo. Housing finance system provides subsidy for purchase or construction of ownership houses. Though there are some restrictions regarding the size of houses. These restrictions to a large extent determine the type of housing supplied in Tokyo. The results also support the view that with increase in income, the market share of multi-family ownership houses would increase much larger than single family ownership houses. Affordability is the major criteria determining the choice in favour of multi-family houses.

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Appendix 1: Design of Alternatives

The design of alternatives is very important for discrete choice analysis of housing demand. In Japan, there is wide difference between rental and owner house area. In 1999, the average area of ownership house in Japan is 121 square meter as compared to 45 square meter in case of rental houses (Figure A.1). There has been steady improvement in average area of ownership houses but average rental house area has not changed much. The distribution of rental houses with area (Figure A.2) indicates that 73% of rental houses have area less than 50 square meter. Another 17% of rental houses have area between 50 and 70 square meter.

Table A.1: Statistics relevant for the tree structure

Number of Rooms	Percentage Share	
Up to 4	68%	
5 or more	32%	
Room-Tenure Cross Tabulation		
	Owner (100%)	Rental (100%)
Up to 4	42%	97%
5 or more	58%	3%
Room-Unit type Cross Tabulation		
	Single family (100%)	Multi family(100%)
Up to 4	36%	92%
5 or more	64%	8%
Room-Unit type Cross Tabulation – By Tenure		
Ownership houses		
	Single family (100%)	Multifamily (100%)
Up to 4	29%	74%
5 or more	71%	26%
Rental houses		
	Single family (100%)	Multifamily (100%)
Up to 4	85%	99%
5 or more	15%	1%
Tenure- Unit type Cross Tabulation		
	Single family	Multi family
Owner houses (100%)	71%	29%
Rental houses (100%)	15%	85%

Table A.2: Minimum and targeted standards recommended by Government in Japan

No of Persons	Minimum Standard		Targeted Standard	
1	1DK(2 rooms)	25 Sqm	1DK(2 rooms)	43Sqm
2	1DK(2 rooms)	29Sqm	1LDK(3 rooms)	55Sqm
3	2DK(3 rooms)	39Sqm	2LDK(4 rooms)	75Sqm
4	3DK(4 rooms)	50Sqm	3LDK(5 rooms)	91Sqm
5	3DK(4 rooms)	56Sqm	4LDK(6 rooms)	104Sqm
6	4DK(5 rooms)	66Sqm	4LDK(6 rooms)	112Sqm

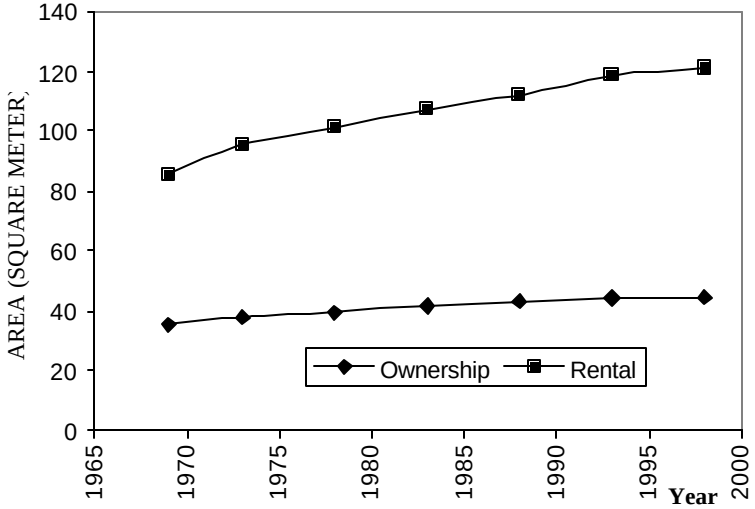
Source: A Quick Look at Housing in Japan, 4th Edition, 1998, The Building Center of Japan, Tokyo.

Note: Japanese houses have combined use of living room, dining room and kitchen either all three together or two of these components together.

L referes to living
D refers to Dining
K referes to kitchen

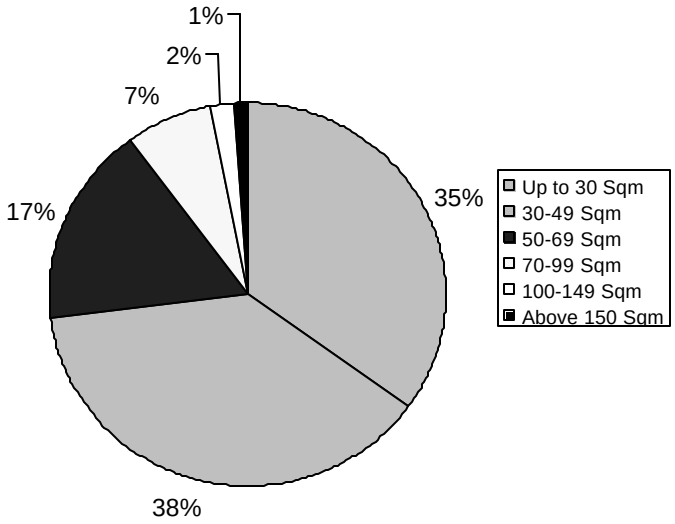
The distribution of houses by tenure (rental versus ownership), size (small versus large) and unit type (single family versus multi family) is skewed at times. As shown in table A.1, there are 68% of houses, which have less than 5 rooms and 32% of houses have 5 or more rooms. Tenure wise distribution indicates that most of 5 or more room houses are ownership houses (58%). Only three percent of rental houses have 5 or more rooms. Unit type wise as well, most of the large houses (5 or more rooms) belong to single family houses (64%) and only 8% of multi family houses have 5 or more rooms. It becomes difficult to design housing alternatives.

Figure A.1: Average House Size in Japan (sqm.)



We use another information to supplement our data to enable us in designing alternatives. Japanese Government has laid down policies for minimum and targeted standards for households (table A.2). A household with 4 members should have a minimum of 50 square meter (4 rooms) and targeted 91 square meter (5 rooms) house.

Figure A.2: Distribution of Rental Houses by Size in Japan



Based on above information we classify housing choices in following eight alternatives.

1. R-S-14: Rent, single family house, 1-4 rooms
2. R-SF-5: Rent, single family house, 5+ rooms
3. R-MF-14: Rent, multi-family house, 1-4 rooms
4. R-MF-5: Rent, multi-family house, 5+ rooms
5. O-SF-14: Own, single family house, 1-4 rooms
6. O-SF-5: Own, single family house, 5+ rooms
7. O-MF-14: Own, multi-family house, 1-4 rooms
8. O-MF-5: Own, multi-family house, 5+ rooms