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The Estimation of Owner Occupied Housing Indexes using the RPPI: The Case of Tokyo*

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Abstract

Dramatic increases and decreases in housing prices have had an enormous impact on the economies of various countries. If this kind of fluctuation in housing prices is linked to fluctuations in the consumer price index (CPI) and GDP, it may be reflected in fiscal and monetary policies. However, during the 1980s housing bubble in Japan and the later U.S. housing bubble, fluctuations in asset prices were not sufficiently reflected in price statistics and the like. The estimation of imputed rent for owner-occupied housing is said to be one of the most important factors for this. Using multiple previously proposed methods, this study estimated the imputed rent for owner-occupied housing in Tokyo and clarified the extent to which the estimated imputed rent diverged depending on the estimation method. Examining the results obtained showed that, during the bubble's peak, there was an 11-fold discrepancy between the Equivalent Rent Approach currently employed in Japan and Equivalent Rent calculated with a hedonic approach using market rent. Meanwhile, with the User Cost Approach, during the bubble period when asset prices rose significantly, the values became negative with some estimation methods. Accordingly, we estimated Diewert's OOH Index, which was proposed by Diewert and Nakamura (2009). When the Diewert's OOH Index results estimated here were compared to Equivalent Rent Approach estimation results modified with the hedonic approach using market rent, it revealed that from 1990 to 2009, the Diewert's OOH Index results were on average 1.7 times greater than the Equivalent Rent Approach results, with a maximum 3-fold difference. These findings suggest that even when the Equivalent Rent Approach is improved, significant discrepancies remain.

Key Words :Durable goods; Consumer Price Index; Owner Occupied Housing; hedonic regression models; rental equivalence approach; user cost approach; RPPI handbook

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1 Introduction

Housing price fluctuations exert effects on the economy through various channels. More precisely, however, relative prices between housing and other assets prices and goods/services

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prices are the variable that should be observed.

Even if both assets and goods/services prices (and wages) double, the assets price hike alone may have little impact on the economy. In reality, however, housing prices posted substantial hikes and declines both in Japan and the United States while goods/services prices represented by consumer price indexes moved little (Diewert and Nakamura (2009),(2011)), Shimizu and Watanabe (2010)). Why? Given the substantial hikes and declines in housing prices, Shimizu, Nishimura and Watanabe (2010) look into why the substantial housing price fluctuations did not spill over to goods/services prices.

Housing rents are the most important variable for an analysis of housing price fluctuations' spillover effects on goods/services prices. Housing services account for more than a quarter of consumers' typical consumption in Japan and the United States. Therefore, if housing price hikes spill over to housing rents, consumer prices may soar. Goodhart (2001) said housing rents are a joint between assets and goods/services prices.

In order to understand why housing price fluctuations fail to spill over to consumer prices, we may have to check how housing price fluctuations spill over to housing rents. Let us look into characteristic differences between new and renewal rents.

Summarizing the Shimizu, Nishimura and Watanabe (2010)'s findings, we can conclude that while there is some mechanism for new rents to come closer to market prices, long-term relationships between house owners and tenants, as well as legal regulations, have made it difficult for renewal rents to come closer to market levels. This is one of the reasons for the absence of any close link between the CPI rent and housing prices.

The absence is also attributable to a method for measuring the CPI rent. The CPI rent includes a conventional rent and an imputed rent representing the price of housing services that a house owner receives. In Tokyo, for example, the conventional rent portion accounts for about 20% of the total rent and the imputed rent for about 80%. The imputed rent thus captures the greater part of the total rent. Conceptually, the imputed rent is a rent level that a house owner can receive when leasing the house in the rental house market today. Therefore, the imputed rent always matches the market price.

For example, Diewert and Nakamura (2009),(2011) defined the imputed rent as the services yielded by the use of a dwelling by the corresponding market value for the same sort of dwelling for the same period of time. When measuring the CPI rent, however, the Ministry of Internal Affairs and Communications collects data of real rents applied to apartment and other houses since market prices are practically difficult to survey. As noted above, such rent data include renewal rents that deviate from market prices and have little link to housing prices. Therefore, the CPI rent that substitutes renewal rents for the imputed rent has little link to housing prices.

How serious is the problem in practice? Shimizu, Nishimura and Watanabe (2010) estimated the imputed rent using market rents measured through turnover of contracted rents. Specifically, the study replaced the imputed rent out of all CPI components with the new imputed market rent index, left the other CPI components untouched and computed a New CPI. Estimation results indicate that the New CPI inflation rate exceeded the Real CPI inflation by more than 1 percentage point during the bubble period in the second half of the 1980s. When the bubbles burst in the first half of the 1990s, the New CPI inflation was some 2 percentage points less than the Real CPI inflation. Particularly interesting is the timing for the start of deflation. The New CPI inflation became negative in early 1993, some two years before the real CPI inflation turned negative in 1995. The estimation indicates that the replacement of imputed rent data with a more desirable indicator contributes to increasing housing prices' link to the CPI.

This kind of distortion in the estimation of imputed rent for owned-occupied housing causes major problems with respect to CPI changes.

The distortion in the estimation of imputed rent for owner-occupied housing is not just a CPI problem. The imputed rent for owner-occupied housing also represents a weight of approximately 10% in the system of national accounts (SNA). And with regard to GDP size and fluctuations, imputed rent for owner-occupied housing is the most important indicator for fiscal and monetary policies (along with the CPI), and at the same time, it is expected that the proportion accounted for by it will grow increasingly larger in future. On the other hand, it has also been pointed out that estimation of imputed rent for owner-occupied housing is the most difficult estimation subject when generating economic statistics, with various estimation methods having been proposed.

In terms of estimation methods for imputed rent for owner-occupied housing, the leading methods include the Equivalent Rent Approach, which extrapolates rent based on the surrounding rental market, and the User Cost Approach, which estimates rent using housing asset prices. However, problems have been pointed out with both of these methods.
What kind of method should be used in the estimation of imputed rent for owner-occupied housing? What level of disparity arises based on the different calculation methods?

In order to answer such questions, this study will, taking Diewert and Nakamura (2009),(2011) as a starting point, estimate the imputed rent for owner-occupied housing in Tokyo using multiple previously proposed methods, with the aim of clarifying the level of difference arising due to the disparities between calculation methods.

In the 2010 national census, there were 13,161,751 people living in Tokyo (6,403,219 households), with an SNA production value of ¥71.181 trillion, of which imputed rent for owner-occupied housing accounted for ¥3.0621 trillion. The figures for both population and economic power are comparable in size to those of a small country. As well, during the latter half of the 1980s, a steep rise in real estate prices occurred, but following the collapse of the bubble in 1990, housing prices declined steadily over a long period. Given such a large-scale fluctuation in housing prices, we believe that clarifying the level of the differences that arise in imputed rent for owner-occupied housing calculated with different methods will be extremely significant when applying them to various countries in future.

2 The Theory of Household User Costs

2.1 Basic model of User Cost Approach

Katz (2009) reviews the theoretical framework that can be used to derive both user cost and rental equivalence measures from the fundamental equation of capital theory:

"The user cost of capital' measure is based on the fundamental equation of capital theory. This equation, which applies equally to both financial and non-financial assets... states that in equilibrium, the price of an asset will equal the present discounted value of the future net income that is expected to be derived from owning it."

The user cost of capital measure provides an estimate of the market rental price based on costs of owners. It is directly derived from the assumption that, in equilibrium, the purchase price of a durable good will equal the discounted present value of its expected net benefits; i.e., it will equal the discounted present value of its expected future services less the discounted present value of its expected future operating costs. To see this, let V_v^t denote the purchase price of a v year old durable at the beginning of year t; let V_{v+1}^{t+1} denote the expected purchase price of the durable at the beginning of year $t+1$ when the durable is one year older; let u_v^t denote the expected end of period value of the period t services of this durable; let O_v^t denote the expected period t operating expenses to be paid at the end of period t for the v year old durable; and let r^t denote the expected nominal discount rate (i.e., the rate of return on the best alternative investment) in year t.

Expected variables are measured as of the beginning of year t.

Assume the entire value of the durable's services in a year will be received at the year's end, and that the durable is expected to have a service life of m years. From the definition of the discounted present value, we have

$$\begin{aligned} V_v^t = & \frac{u_v^t}{1+r^t} + \frac{u_{v+1}^{t+1}}{(1+r^t)(1+r^{t+1})} + \cdots + \frac{u_{m-1}^{t+m-v-1}}{\Pi_{i=t}^{t+m-v-1}(1+r^i)} \\ & - \frac{O_v^t}{1+r^t} - \frac{O_{v+1}^{t+1}}{(1+r^t)(1+r^{t+1})} - \cdots - \frac{O_{m-1}^{t+m-v-1}}{\Pi_{i=t}^{t+m-v-1}(1+r^i)} \end{aligned} \tag{1}$$

When the durable is one year older, the expected price of the durable at the beginning of year $t+1$ is:

$$\begin{aligned} V_{v+1}^{t+1} = & \frac{u_{v+1}^{t+1}}{1+r^{t+1}} + \frac{u_{v+2}^{t+2}}{(1+r^{t+1})(1+r^{t+2})} + \cdots \\ & + \frac{u_{m-1}^{t+m-v-1}}{\Pi_{i=t+1}^{t+m-v-1}(1+r^i)} - \frac{O_{v+1}^{t+1}}{1+r^{t+1}} - \cdots - \frac{O_{m-1}^{t+m-v-1}}{\Pi_{i=t+1}^{t+m-v-1}(1+r^i)} \end{aligned} \tag{2}$$

Dividing both sides of (2) by $(1+r^t)$ and subtracting the result from equation (1) yields

$$V_v^t - \frac{V_{v+1}^{t+1}}{1+r^{t+1}} = \frac{u_v^t}{1+r^t} - \frac{O_v^t}{1+r^t} \tag{3}$$

Multiplying through equation (3) by $(1+r^t)$ and combining terms, one obtains the end of period $_t$ user cost:

$$u_v^t = r^t V_v^t + O_v^t - (V_{v+1}^{t+1} - V_v^t) \tag{4}$$

The estimated market value of a home a year later (V_{v+1}^{t+1}) is computed in the context that the home has a remaining service life for the homeowner of m years.

2.2 The Verbrugge Variant (VV) of the User Cost Approach

The specification of the user cost implemented in Poole, Ptacek and Verbrugge (2005) is based on derivations presented in Verbrugge (2008), where alternative ways of handling the home value appreciation term are also investigated more fully. Here, we label the formulation of the user cost presented as equation (1) in Verbrugge (2008) as the Verbrugge variant, hereafter referred to for short as the VV user cost.

The VV user cost is derived by treating homeowners as though they costlessly sell and buy back their homes each year.[1] Stated using our notation, where V^t is the beginning of period value of the home ignoring, as Verbrugge does, the age of the home; r^t is a nominal interest rate; V^t is a term which collects the rates of depreciation, maintenance, and property taxes; and $E[\pi]$ is an estimate of the rate of expected house price appreciation, the VV user cost formula is:

$$u^t = r^t V^t + \gamma_H^t V^t - E[\pi] V^t \tag{5}$$

=forgone interest+operating costs-expected (t) to (t+1) change in home value.

Verbrugge experiments with a number of alternative ways of measuring the final term of (5) for the expected change in home value from the beginning to the end of year t, but his preferred forecasting equation includes a forecast of the home price change based on 4 quarters of prior home price information. With this setup, changes in home prices have an immediate within-year impact on the user cost. When home prices are rising, the final term of (5) serves to offset the contribution of the first term, $r^t V^t$.

2.3 Diewert's OOH Opportunity Cost Approach

The time has come, we feel, to accept the evidence of Verbrugge and others that user costs and rents do not reliably move together! This verdict implies we must rethink the approach

[1]This user cost variant follows naturally from application of the statement of the user cost approach given by Diewert (1974) in the opening quotation for section 3 about how a consumer is imagined to be buying their home and then selling it back each period – (possibly to himself). We note that in section 6 of his paper, Verbrugge (2008) relaxes the assumption that there are no costs of buying and selling a house and he uses this fact to try to help explain the divergence between the rental price of a home and its user cost.

for accounting for OOH in the price statistics of nations. We argue in the rest of this paper for a shift to the new opportunity cost approach for accounting for the cost of housing.

The term opportunity cost refers to the cost of the best alternative that must be forgone in taking the option chosen. Thus, we seek to compare implications for homeowner wealth of selling at the beginning of period t with the alternatives of planning to own a home for m more years and of either renting out or occupying the home for the coming year. This comparison is assumed to be carried out at the beginning of period t based on the information available then about the market value of the home and interest rates and the forecasted average increase per year in home market value if the home is held for another m years.

Refinancing can be viewed as a way of a homeowner selling or buying back a fraction of an owned home. In contrast to selling and buying titles to properties, financing and refinancing costs for mortgages and other loans secured by liens on property titles are quite low, in the United States at least. We imagine that a homeowner mentally notes at the start of each year the market price and the forecast for the annual average growth in value for a home that the owner expects to hold for m more years. The homeowner is presumed to use this information as input to decisions made at the start of the year on whether to adjust their debt for the coming year, whether to sell at the start of the year or to plan on continuing to own their home for m more years, and whether to rent out or occupy the home for the coming year if they continue to own it.

Owner occupiers in period t continue to own their homes with the chosen levels of debt, and to occupy rather than renting their homes out. Thus in choosing to own and occupy, they pass up the opportunity of selling at the start of the period, and also the opportunity of renting out their home that year. At the level of an individual homeowner, the opportunity cost approach amounts to treating the cost to the owner occupant of their housing choice as the greater of the foregone benefit they would have received by selling at the start of period t or renting out the owned home and collecting the rent payments.

The owner occupied housing opportunity cost index can now be defined as follows:

For each household living in owner occupied housing (OOH), the owner occupied housing opportunity cost (OOHOC) is the maximum of what it would cost to rent an equivalent dwelling (the rental opportunity cost, ROC) and the financial opportunity costs (FOC).

The OOHOC index for a nation is defined as an expenditure share weighted sum of a rental equivalency index and a financial opportunity cost index, with the expenditure share weights depending on the estimated proportion of owner occupied homes for which FOC exceeds ROC.

The Rental Opportunity Cost Component The rental opportunity cost component is operationally equivalent to the usual rental equivalency measure, but the justification for this component here does not rest on an appeal to the fundamental equation of capital theory and is not tied to the potential sale value for the home in the current or subsequent periods. In the present context, the ROC component is simply the rent for period t on an owned dwelling that the owner forgoes by living there that period. That is, it is the rent the owner could have collected by renting the place out rather than living there.[2]

We next turn our attention to the financial opportunity cost of the money tied up in an owned dwelling. A home, once purchased, can yield owner occupied housing services over many years. The user cost framework provides guidance on how to infer the period-by-period financial costs of OOH services using the observable home purchase data.

We can use the user cost framework this way even in situations when the capital theory assumptions under which the user cost equals the expected rent are not satisfied.

The Financial Opportunity Cost Component The user cost formulation we recommend for the FOC component of the opportunity cost is referred to here as the Diewert variant, or DV, user cost. For this specification, we let r^t denote the rate of return a homeowner could have received by investing funds that are tied up in the owned home. In addition, we take account of the fact that many homeowners have debt that is secured against their homes and must make regular specified payments on that debt to continue to be in a position to occupy or to rent out their homes.

Research has shown that owner occupied homes, on the whole, exhibit little physical depreciation over time given modern standards for home maintenance.[3] (This is in contrast to the situation for rental housing units that have been shown to lose significant value, on average, with increasing age.) Hence, since we are focusing on owner occupied housing here, we drop the dwelling age subscript v from this point on, as we did in introducing the Verbrugge variant (VV) user cost in equation (5).

We also take account of the fact that the vast majority of homeowners own their homes for many years. Indeed, if we take account as well of the phenomenon of serial home ownership, with owner occupiers rolling forward the equity accumulated from one owned home to the next, then the time horizon should arguably be the entire number of years a homeowner plans to continue to live in owned housing. Many people move into their own owned homes as soon as they can afford to after reaching adulthood and die still owning their own homes. The expected remaining years, m, until a homeowner expects to withdraw all the equity they have in their home is an important parameter for determining the FOC component. However, if homeowner-specific information about m is lacking, perhaps m could be set at a value no lower than the median years that homeowners report having been in their present homes.

Having stated the above choices and views, we are now ready to specify the FOC compo-

[2]Notice that, in computing the ROC component, we do not subtract the cost the owner would need to incur to live somewhere else if they rented the home out. The opportunity cost of living in an owned home, which is the maximum of the ROC and FOC components, is what the person would presumably compare with the costs of alternative housing arrangements in making their choice about where to live for period t. It does, however, make sense to think of the ROC value for an individual homeowner as a lower bound on the value they place on living in the home in light of the fact that most people, in the United States at least, seem to have a strong preference for living in owned accommodations.

[3]Here normal maintenance for owned homes is essentially being defined to include the amount of maintenance and renovation expenditures required to just maintain the overall quality of the home at a constant level.

nent for an individual homeowner. Here we ignore the case of homeowners who have negative home equity: a more complex and obviously important case in the present circumstances which we are considering now in separate research with Leonard Nakamura. We also abstract from transactions costs and taxes: further complications that we are also considering in our new research with Leonard Nakamura.

As of the start of period t, a homeowner with nonnegative equity could sell, paying off any debt (D^t) in the process, and could collect the (non negative) sum of $V^t - D^t$. Or the homeowner could choose to continue owning the dwelling, in which case they must make payments on any debt they have, and must pay the normal home operating costs; they must do this whether they choose to live in their home or rent it out for the coming year. If they continue to own the dwelling - either living in it or renting it out – they will forego the interest they could have earned on the equity tied up in their home and will incur maintenance costs and carrying costs on any debt, but they will also enjoy any capital gains or incur any capital losses that materialize.

The financial user cost for owning the home in period t and living in it, discounted to the start of period t , is:

$$\frac{u^t}{1+r^t} \equiv [V^t - D^t] - \left[\frac{-r_D^t D^t - O^t + (\overline{V^{t+1}} - D^t)}{1+r^t}\right], \tag{6}$$

where $\overline{V^{t+1}}$ is the value of the home at the beginning of period t plus the expected average appreciation of the home value over the number of years before the homeowner plans to sell. Thus, the second term in square brackets is the forecasted expected value of the home as of the end of period t which is the beginning of period t+1 ($\overline{V^{t+1}}$) minus the period t debt service costs ($r_D^t D^t$) and operating costs (O^t) that must be paid in order to either occupy or rent out the dwelling for period t. If we multiply expression (6) through by the discount factor, $1 + r^t$, we now obtain an expression for the ex ante end of period user cost:

$$u^t \equiv r_D^t D^t + r^t(V^t - D^t) + O^t - (\overline{V^{t+1}} - V^t). \tag{7}$$

The importance of the debt related terms in (6) and (7) can be better appreciated by considering some specific types of homeowners. Consider a type A homeowner who owns their home free and clear. For them, the end of period user cost for period t, discounted to the start of the period, is:

$$\frac{u^t}{1+r^t}\,|_{typeA} \equiv [V^t] - \left[\frac{-O^t + \overline{V^{t+1}}}{1+r^t}\right] = \frac{O^t + r^t V^t - (\overline{V^{t+1}} - V^t)}{1+r^t}. \tag{8}$$

The user cost considered as of the end of the period is found by multiplying (8) through by $1 + r^t$, yielding:

$$u^t\,|_{typeA} \equiv r^t V^t + O^t - (\overline{V^{t+1}} - V^t). \tag{9}$$

Notice that this is essentially the customary user cost expression, as derived by Katz (2009) and others. This is the same basic formulation used as well by Verbrugge; e.g., see (5) above.

Type B homeowners do not fully own their homes, but have positive home equity: the most prevalent case for U.S. homeowners. If the homeowner were to sell at the beginning of period t, the realized proceeds of the sale (after repaying the debt) would be $V^t - D^t$. The end of period user cost for period t for these homeowners, discounted to the start of period t, is:

$$\frac{u^t}{1+r^t}\,|_{typeB} \equiv [V^t - Dt] - \left[\frac{-r_D^t D^t - O^t + (\overline{V^{t+1}} - D^t)}{1+r^t}\right] \quad (10)$$
$$== \frac{r_D^t D^t + O^t + r^t(V^t - D^t) - (\overline{V^{t+1}} - V^t)}{1+r^t}$$

The user cost, as of the end of the period, is found by multiplying (10) through by $1+r^t$:

$$u^t\,|_{typeB} \equiv r_D^t D^t + r^t(V^t - D^t) + O^t - (\overline{V^{t+1}} - V^t). \quad (11)$$

Type C homeowners have zero home equity. In this case, if the homeowner sells at the start of period t, we assume simply that they get nothing from the sale. And if they continue to own and live in the home, they do so without having any equity tied up by this choice and hence are not foregoing any earnings on funds tied up in their home. The end of period user cost for period t, considered as of the start of period t, is:

$$\frac{u^t}{1+r^t}\,|_{typeC} \equiv -\left[\frac{-r_D^t D^t - O^t + (\overline{V^{t+1}} - D^t)}{1+r^t}\right]. \quad (12)$$

The user cost considered as of the end of the period is:[4]

$$u^t\,|_{typeC} \equiv r_D^t D^r + O^t - (\overline{V^{t+1}} - V^t). \quad (13)$$

We next consider the extreme case in which the interest rate for borrowing equals the returns on investments (i.e., $r_D^t = r^t$). Now, (10) and (11) reduce to (8) and (9). That is, the expressions for the homeowners who have debt but still have positive equity in their homes reduce to the expressions for the user cost for the homeowners who own their dwellings free and clear. We see, therefore, that the traditional user cost expression, as derived by Katz, and the VV user cost implicitly assume that homeowners who have mortgages or other home equity loans are charged an interest rate on this debt that equals the rate of return on their financial investments.

Most well off households have mostly low cost debt whereas many poor households mostly have high cost debt. The importance of this fact can be demonstrated using the end of

[4]Note that in this zero equity case, it seems like the payments approach is justified at first glance. However, the payments approach neglects the expected capital gains term and during periods of high or moderate inflation, this term must be taken into account.

period user cost for a type B homeowner. For a homeowner who has positive home equity and only low cost debt with $r_D^t < r^t$, expression (11) can be written as:

$$u^t\,|_{typeB} \equiv r_D^t D^t + r^t(V^t - D^t) + O^t - (\overline{V^{t+1}} - V^t) \\ == r_D^t V^t - (r^t - r_D^t)D^t + O^t - (\overline{V^{t+1}} - V^t), \tag{14}$$

where the term $(r^t - r_D^t)$ is positive. Hence, for these homeowners, higher debt reduces the financial cost of OOH services. Indeed, this is a potential motivation for a Type B homeowner to increase their low cost borrowing to the greatest extent possible. The only rational constraint on doing this, from an economic perspective, is that higher debt can also bring a greater risk of home foreclosure or personal bankruptcy in the event of a downturn in the economy or personal problems such as job loss or illness.

The case of a homeowner with only high cost debt (i.e., with $r_D^t > r^t$) is different. Now (11) reduces to:

$$u^t\,|_{typeB} \equiv r_D^t D^t + r^t(V^t - D^t) + O^t - (\overline{V^{t+1}} - V^t) \\ == r^t V^t + (r_D^t - r^t)D^t + O^t - (\overline{V^{t+1}} - V^t), \tag{15}$$

where $(r_D^t - r^t)$ is positive. So now, higher debt means a higher financial cost of OOH services. Most subprime loans are high cost, with interest rates at least three interest rate points above Treasures of comparable maturities.

We come now to the question of how the DV user cost would behave over a housing bubble. In this portion of our analysis, we use the general (8) expression for the end of period user cost. Moreover, we will define $r_{H(m)}^t$ as the expected rate of home price change under the assumption a home will be held for m more years. Now, (7) can be rewritten as

$$u^t \equiv r_D^t D^t + r^t(V^t - D^t) - r_{H(m)}^t V^t + O^t \\ == (r_D^t - r^t)D^t + (r^t - r_{H(m)}^t)V^t + O^t, \tag{16}$$

where

$$r_{H(m)}^t V^t = \overline{V^{t+1}} - V^t$$

Hence the FOC for a household can be negative when, for example, the borrowing rate is less than the expected rate of return on financial assets, and the expected rate of return on financial assets is less than the expected annual rate of return on housing assets.

However, the OOHOC for a household will never be zero or negative because it is defined as the maximum of the ROC and the FOC, with the rental opportunity cost necessarily being positive.

Notice also that the FOC component will rise as home prices rise, and first and foremost, when the expected rate of return on financial investments (r^t) is greater than the expected rate of return on the housing asset ($r^t_{H(m)}$). Going into a bubble, the first term,

$$(r^t_D - r^t)D^t,$$

will be hard to forecast even in terms of sign, but we would expect the changes in this term to be small compared to the changes in the second term,

$$(r^t - r^t_{H(m)})V^t$$

During the expansion phase of a bubble, home values, and hence V^t , will grow rapidly, but the longer run return on housing assets should not change as much and hence the financial user cost of OOH, given by equation (16), should increase. This result underlines the importance of incorporating longer run expectations into the user cost formula. Of course, when the bubble bursts, the financial user cost will rapidly decline, although the decline will be offset somewhat by the possible decline as well in $r^t_{H(m)}$.[5]

3 Empirical Analysis

3.1 Estimation Error of Imputed rent for OOH

Targeting the owner-occupied housing market in Tokyo, after collecting as much micro-data as possible, we estimated imputed rent for owner-occupied housing using multiple methods.

First, we calculated it with the Equivalent Rent Approach currently employed in Japan.

The Equivalent Rent Approach is a method that forecasts housing rent levels in the case of leasing out owner-occupied housing, using housing rental rates formed by the housing rental market. In the case of attempting to estimate imputed rent for owner-occupied housing with such a method, it has been pointed that bias occurs due to data limitations and market structure disparities between the owner-occupied housing market and the rental housing market.

For example, according to the 2008 Housing and Land Survey, the average floor space (size) of owner-occupied housing in Tokyo was 110.71 square meters for single-family house owner-occupied housing and 79.36 square meters for rental housing – a discrepancy of over 30 square meters. When it comes to condominiums, an even greater discrepancy exists, at 65.84 square meters for owner-occupied housing and 36.06 square meters for rental housing. Moreover, it is not just the area – a quality gap in structure, facilities, etc., also exists between owner-occupied housing and rental housing. As a result, when attempting to estimate imputed rent for owner-occupied housing using rental housing data, it is necessary to perform quality adjustment.

[5] Locked in aspects of the financing arrangements of home buyers may also matter in this regard. We are exploring this issue now in a follow-up study.

However, in estimating imputed rent for owner-occupied housing in Japan, the average rent calculated for either the country as a whole or individual prefectures is multiplied by the aggregate owner-occupied housing area. In this case, since many rental housing units are concentrated in urban areas, the average housing rent that is estimated is heavily weighted on urban data. In such a situation, there is a strong possibility of overestimating imputed rent. Meanwhile, since most rental housing units are small-scale housing of 30 square meters or less, the quality is considerably inferior. In this case, there is a strong possibility of underestimating imputed rent. As well, since it is known that housing rents and prices change significantly based on the location and building age, it is surely natural to think that major measurement errors will arise if adjustment for quality differences is not performed.

Besides these kinds of problems based on structural differences between the owner-occupied housing and rental housing markets, problems also exist in terms of the nature of the rent being surveyed. Since the rent surveyed via the Housing and Land Survey and consumer price statistics is the household's paying rent, there is a strong possibility that there is a major discrepancy with the rent determined by the current market.

The reason for this is that the lease contract period in Japan is two years, so the rent is not changed for a two-year period after the contract is concluded (in Canada it is one year, and rent is mostly not changed over the one-year period). As well, even if the lease contract is renewed, it is rare for the rent to be revised to the same level as market rent at the time of contract renewal. As a result, the rent that would likely be generated by the market at the time of the survey and the rent being paid at that time diverge significantly (see Shimizu, Nishimura, and Watanabe, 2010).[6]

Accordingly, we implemented two corrections for the Equivalent Rent Approach. The first correction was an adjustment to the rent data. We changed the household paying rent surveyed by the CPI and Housing and Land Survey to the market rent formed at that time. The second correction was the implementation of quality adjustment. Different rents are set depending not only on regional differences (such as proximity to city) but also on differences within the same region, such as floor space, distance to nearest station, time to city center, building age, etc. Adjustment of such quality differences was performed using the hedonic approach.

Next is the User Cost Approach, which attempts to estimate imputed rent from the asset price of owner-occupied housing. The estimation method for doing so is complicated, and it has been pointed out that there is a problem with the value becoming negative during periods of dramatic price increases. It has also been noted that this is combined with the problem of housing price volatility becoming greater than what it is perceived by market players. However, a Residential Property Price Handbook (RPPI Handbook) is published

[6]Since the Japanese Act on Land and Building Leases strongly protects renters, increasing rent is prohibited except in cases where it is allowed due to a rise in costs such as property taxes. As a result, even when housing prices rise significantly, it is difficult to change the rent during the lease contract term. As well, even when a lease contract is renewed, increases in the rent amount are not allowed to exceed the extent of cost increases.

for estimating housing prices[7], and it is anticipated that in future many countries will move forward with aligning their housing price statistics based on this handbook.[8]

Accordingly, in employing the User Cost Approach, we calculated the single-family housing price function and condominium price function using the hedonic approach recommended by the RPPI Handbook, and then calculated the quality-adjusted asset price. Furthermore, in the User Cost calculation, it is necessary to consider various costs. Among these, property tax has the greatest weight. The land evaluation amount for property tax varies considerably based on location. We therefore calculated a hedonic function based on published land value data that is the benchmark for property tax land evaluations, and combined it with the property tax amount for each type of dwelling unit.[9]

3.2 Data

3.2.1 Housing rents, housing prices and land prices

We collect housing prices and rents from a magazine or website, published by Recruit Co., Ltd., one of the largest vendors of residential lettings information in Japan. The Recruit dataset covers the 23 special wards and Tama-area of Tokyo for the period 1986 (Rents: 1990) to 2010, including the bubble period in the late 1980s and its collapse to the 90s. It contains 251,473 listings for single family house prices, 330,247 listings for condominium prices and 1,155,078 listings for rents of single family houses and condominiums.[10] Recruit provides time-series of housing prices and rents from the week when it is first posted until the week it is removed because of successful transaction.[11] We only use the price in the final week because this can be safely regarded as sufficiently close to the contract price.[12]

In addition, in order to calculate property tax amounts, we developed published land

[7]See http://epp.eurostat.ec.europa.eu/portal/page/portal/hicp/methodology/owner_occupied_housing_hpi/rppi_handbook with regard to the RPPI Handbook.

[8]In Japan, the publication of the RPPI Handbook has led to an office being set up within the Ministry of Land, Infrastructure, Transport and Tourism, and advisory board aimed at real estate price index upgrading being implemented through interaction between the Bank of Japan and Financial Services Agency (which are responsible for fiscal policy), the Cabinet Office (which is responsible for SNA statistics), the Ministry of Internal Affairs and Communications Statistics Bureau (which is responsible for consumer price statistics), the Ministry of Justice (which is responsible for housing relocation statistics), and private-sector experts, and progress being made toward establishing a new housing price index. A new housing price index using the method recommended in the RPPI Handbook is scheduled to be published during fiscal 2012. The coordination of such statistics across Japan as a whole is significant not just as a benchmark for making fiscal and monetary decisions but also for creating the possibility of applying them to other statistics – the estimation of imputed rent for owner-occupied housing being a leading example.

[9]Land evaluation for property tax purposes is determined using 70% of the published land price as a base. For this study, we started by calculating the land price evaluation level using the published land price base.

[10]Shimizu et al. (2010) report that the Recruit data cover more than 95 percent of the entire transactions in the 23 special wards of Tokyo. On the other hand, its coverage for suburban areas is very limited. We use only information for the units located in the special wards of Tokyo.

[11]There are two reasons for the listing of a unit being removed from the magazine: a successful deal or a withdrawal (i.e. the seller gives up looking for a buyer and thus withdraws the listing). We were allowed access information regarding which the two reasons applied for individual cases and discarded those where the seller withdrew the listing.

[12]Recruit Co., Ltd. provided us with information on contract prices for about 24 percent of the entire listings. Using this information, we were able to confirm that prices in the final week were almost always identical with the contract prices (i.e., they differed at a probability of less than 0.1 percent).

price data, which is the benchmark for property tax land evaluations. From 1990 to 2010, evaluation amount data has been published for 37,479 residential areas.

Table1 shows a list of the attributes of a house. This includes ground area (L), floor space (S), and front road width (W) as key attributes of a house. The age of a house is defined as the number of months between the date of the construction of the house and the transaction. We define south-facing dummy, SD, to indicate whether the house's windows are south-facing or not (note that Japanese are particularly fond of sunshine). The convenience of public transportation from each house location is represented by travel time to the central business district (CBD),[13] which is denoted by TT and time to the nearest station,[14] which is denoted by TS. We use a ward dummy, *WD*, to indicate differences in the quality of public services available in each district, and a railway line dummy, *RD*, to indicate along which railway/subway line a house is located.

Table2 shows the summary statistics for the various data. The average single family house price is ¥66.23 million, while the average condominium price is ¥37.17 million. Looking at the average floor space (S), the figures are 105 square meters for single family houses and 57 square meters for condominiums, which is consistent with Land and Housing Survey results. In other words, the data collected here is largely in accordance with single family housing and condominium stocks.

If one looks at rent data, the average monthly rent is ¥110,000 and the average floor space (S) is 38 square meters. It is clear from the data collected in this study that a significant discrepancy exists between the average housing floor space produced by the owner-occupied housing market and the rental market.

The building age (A) is 15 years for single family houses, 14 years for condominiums, and 9 years for rental housing. Here, too, one can see that there is a significant discrepancy between the owner-occupied housing market and rental market.

3.2.2 Building Usage Data

With regard to building usage, we used the Tokyo current land and building usage survey data. This data provides information on usage status, structure, number of stories, and floor space for all buildings in Tokyo at four points in time (1991, 1996, 2001, and 2006) via an inventory survey. What's more, it is provided as a database that can be used via the Geographic Information System (GIS). With regard to housing, this study employs four types of building usage: single family houses, condominiums, housing joint industrial usage,

[13]Travel time to the CBD is measured as follows. The metropolitan area of Tokyo is composed of 23 wards centering on the Tokyo Station area and containing a dense railway network. Within this area, we choose seven railway/subway stations as the central stations, which include Tokyo, Shinagawa, Shibuya, Shinjuku, Ikebukuro, Ueno, and Otemachi. Then, we define travel time to the CBD by the minutes needed to commute to the nearest of the seven stations in the daytime.

[14]The time to the nearest station, TS, is defined as walking time to a nearest station if a house is located within the walking distance from a station, and the sum of walking time to a bus stop and onboard time from the bus stop to a nearest station if a house is located in a bus transportation area within walking distance from a station. We use a bus dummy, BD, to indicate whether a house is located in a walking distance area from a station or in a bus transportation area.

Table 1: List of Variables

Symbol	Variable	Content	Unit
S	Floor space	Floor space of building	square meters
L	Ground area	Ground area of housing/building	square meters
W	Road Width	Road width in front of housing	meters
A	Age of building at the time of transaction	Age of building at the time of transaction.	years
TS	Distance to the nearest station	Distance to the nearest station by Walk or Bus or Car.	meters
TT	Travel time to Tokyo station	Average railway riding time in daytime to the Tokyo station.	minutes
SRC	Steel reinforced concrete dummy	Steel reinforced concrete frame structure = 1 Other structure = 0	(0,1)
RC	Reinforced concrete dummy	Reinforced concrete frame structure = 1 Other structure = 0	(0,1)
LGT	Light-gauge steel dummy	Light-gauge steel frame structure = 1 Other structure = 0	(0,1)
Wood	Wood frame structure dummy	Wood frame structure = 1 Other structure = 0	(0,1)
LD_k $(k=0,\ldots,K)$	Location (ward or municipalities) dummy	*k*-th administrative district =1, Other district =0.	(0,1)
RD_l $(l=0,\ldots,L)$	Railway line dummy	*l*-th railway line =1 Other railway line = 0.	(0,1)

Table 2: Summary Statistics of Housing Data

Single family house data:

	Mean	Std. Dev.	Min.	Max.
	Sibngle family house price data (251,473 observations)			
P:price (10,000 Yen) of unit	6,623.83	3,619.20	1,280	29,990
S: Floor space (m^2)	105.48	38.93	50	448
P / *S* (10,000 Yen)	72.47	30.11	25	479
A: Age of building (years)	15.20	8.34	0	55
TS: DIstance to the nearest station (meters)	811.68	374.22	80	2,800
TT: Travel time to terminal station (minutes)	34.48	11.12	1	144
W: Road Width	4.88	1.88	2	20

Condominium price data:

	Mean	Std. Dev.	Min.	Max.
	Condominium price data (330,247 observations)			
P:price (10,000 Yen) of unit	3,717.52	2,250.71	390	33,500
S: Floor space (m^2)	57.83	18.29	15	110
P / *S* (10,000 Yen)	66.22	35.73	25	315
A: Age of building (years)	14.23	8.74	0	55
TS: DIstance to the nearest station (meters)	682.68	366.10	80	2,480
TT: Travel time to terminal station (minutes)	30.10	12.63	1	144

Land price data:

	Mean	Std. Dev.	Min.	Max.
	Land price data (37,479 observations)			
P / *S* (10,000 Yen) per square meter	43.11	40.90	5	1,230
L: Land area (m^2)	191.66	128.75	40	4,069
TS: DIstance to the nearest station (meters)	1,142.28	1,001.50	60	9,200
TT: Travel time to terminal station (minutes)	42.90	16.70	7	126
W: Road Width	5.44	2.45	2	38

Housing rent data:

	Mean	Std. Dev.	Min.	Max.
	Housing rent data (1,155,078 observations)			
P:rent (10,000 Yen/month) of unit	11.23	6.48	2	60
S: Floor space (m^2)	38.27	20.85	10	120
P / *S* (10,000 Yen)	0.31	0.09	0.1	2.0
A: Age of building (years)	9.74	8.11	0	55
TS: DIstance to the nearest station (meters)	614.87	350.25	80	7,040
TT: Travel time to terminal station (minutes)	30.45	11.56	1	126

and housing joint commercial usage.

The fact that data is provided in a form that may be used with the GIS is highly significant. It is known that there are considerable price gaps in housing prices and rent based on location in combination with building characteristics. As a result, one may expect that these location differences will cause significant bias in the estimation of imputed rent for owner- occupied housing. Accordingly, using the GIS, we obtained the "distance to nearest station" and "time to city center(Tokyo station)," which are believed to be key variables in terms of the factors determining housing prices in Tokyo.[15]

However, the data is lacking when it comes to the "Age of building (A)" for each building. Accordingly, we calculated the average building age for single family houses and condominiums by administrative district (city/ward) based on the Housing and Land Survey.[16]

Table3 summarizes building data prepared in combination with Housing and Land Survey data. [17]First, there was little change in single family houses from 1990 (1.857 million houses) to 1995 (1.855 million houses), but the number grew considerably from 2000 (1.897 million houses) to 2005 (2.011 million houses). With regard to condominiums, there were 367,000 units in 1990, 374,000 units in 1995, and 381,000 units in 2000, which rose significantly to 417,000 units in 2005. The increase in total floor space for condominiums was especially significant.

With the Housing and Land Survey, along with the total floor space, it is possible to know the proportion of owner-occupied housing. If we focus on the percentage of owner-occupied housing, the rate was 89% for single family houses in 1990, but in 2005 it had risen to 94%. The rate rose considerably for condominiums as well, from 28% in 1990 to 39% in 2005. We believe the proportion of owner-occupied housing increased during this period because housing prices dropped substantially, along with a reduction in mortgage rates.

3.3 Estimation of Rental Value and Capital Value per Housing

3.3.1 Hedonic Estimation Residential Rent, Condominium, Single Family House and Land.

We estimated a hedonic function using housing rent data, single family house price data, condominium price data, and land price data.

In calculating the rent and housing price by dwelling unit for each year, we estimated the

[15]With regard to the distance to the nearest station, the closest station was defined as the closest station from the center of the building. Based on that, the road distance was measured using the GIS. As well, with regard to the time from the nearest station to Tokyo Station, the average day-time travel time was added, in the same way as for the rental/housing price data.

[16]The Housing and Land Survey includes the number of stocks by year of construction. Accordingly, we calculated the average age of buildings by municipality based on the year of construction, and calculated the Age of Building (A) based on the time elapsed until the time of calculation.

[17]We can see a differences between a) and e), c) and f). The differences come from the survey method. the Tokyo current land and building usage survey is Census, on the other hand, the Housing and Land Survey is Sample survey.

Table 3: Buildings Survey

	Housing Survey						Building Survey			
	Single family house			Condominium			Single family house		Condominium	
	a)Total*	b)Owner occupied housing*	b) / a)	c)Total*	d)Owner occupied housing*	d) /c)	e)Total*	(units)**	f)Total*	(units)***
1990	160,662,570	143,150,350	89.10%	108,909,068	31,452,939	28.88%	148,834,033	1,857,722	107,274,134	367,734
1995	168,371,522	153,351,080	91.08%	135,811,068	42,833,050	31.54%	160,654,688	1,854,315	135,778,868	374,807
2000	185,103,543	167,169,249	90.31%	162,879,280	59,920,560	36.79%	174,379,864	1,897,345	161,698,203	381,216
2005	182,850,330	173,046,939	94.64%	184,044,399	71,923,616	39.08%	181,977,956	2,011,068	186,759,564	417,872

*unit: square meter

**Number of single family houses

***Number of condominium buildings(not unit)

following hedonic function incorporating temporal changes along with structural changes in rent/price formation mechanisms.

$$\mu_{ijt} = X_{it}\beta_t + v_{it} \tag{17}$$

Here, $\mu_{ijt}$is the property rent/price of type j of building i at a point in time t per square meter while j is a characteristic vector relating to the size and building age of the property. j signifies the type of rent or price: single family house price, condominium price, or land price (published land price), along with single family house rent and condominium (apartment building) rent.

As well, it is known that the characteristic price β_t in the hedonic function changes over time (Shimizu et al., 2010). As a result, in order to control for changes in characteristic price β_t as time passes, we estimated hedonic equations for each period t.

The estimation results are shown in Table4 and Table5.

Looking at the hedonic equation estimation results, the coefficient of determination for the single family house price function fluctuates within a range of 0.5 to 0.65, with its explanatory power being lower than that of other models. For single family houses, there is a high degree of heterogeneity compared to the condominium price function, rent function, etc., and we believe it is necessary to incorporate factors such as the surrounding environment. On the other hand, the land price function using real estate appraisal prices has a strong explanatory power, at 0.85 or more across all periods. We believe this is because there is no need to consider the building's structure since it is the land price only and because much of the noise accompanying transactions is eliminated by the real estate appraisal price.

However, for the single family house price function, condominium price function, land price function, and housing rent function alike, the sign functions of the estimated values for

Table 4: Estimation Results of Hedonic Equations 1

	Single family house price model								**Condominium price model**							
Year	Intercept	logS	logW	logA	logTS	logTT	Number	Adj.R^2	Intercept	logS	logA	logTS	logTT	RC	Number	Adj.R^2
1986	4.15	0.04	0.21	-0.05	-0.04	-0.16	2,502	0.53	4.872	-0.019	-0.152	-0.026	-0.179	-0.007	7,604	0.65
1987	4.18	0.02	0.28	-0.03	-0.02	-0.09	2,805	0.66	5.159	0.061	-0.139	0.004	-0.272	-0.034	6,312	0.71
1988	5.02	-0.06	0.26	-0.04	-0.05	-0.13	2,680	0.61	6.058	-0.072	-0.166	-0.018	-0.295	-0.025	7,368	0.72
1989	5.52	0.01	0.23	-0.01	-0.09	-0.24	2,430	0.58	6.386	-0.097	-0.176	-0.030	-0.300	-0.020	15,336	0.73
1990	6.10	-0.08	0.25	-0.02	-0.07	-0.28	2,414	0.54	6.803	-0.143	-0.159	-0.017	-0.334	-0.024	13,680	0.75
1991	6.02	-0.05	0.20	-0.03	-0.09	-0.27	2,430	0.52	6.600	-0.124	-0.195	-0.025	-0.290	-0.027	14,708	0.73
1992	5.82	-0.03	0.14	-0.05	-0.10	-0.23	2,586	0.52	6.397	-0.109	-0.207	-0.026	-0.270	-0.028	17,065	0.70
1993	5.46	-0.06	0.14	-0.04	-0.07	-0.18	2,747	0.51	5.915	-0.048	-0.210	-0.020	-0.239	-0.017	17,647	0.66
1994	5.16	-0.08	0.12	-0.03	-0.04	-0.13	3,775	0.49	5.563	-0.004	-0.224	-0.018	-0.207	-0.020	19,647	0.61
1995	5.25	-0.11	0.09	-0.04	-0.03	-0.13	4,800	0.49	5.213	0.060	-0.254	-0.021	-0.207	-0.015	19,282	0.57
1996	4.99	-0.08	0.11	-0.04	-0.03	-0.13	5,022	0.46	4.933	0.093	-0.244	-0.025	-0.196	-0.015	15,476	0.63
1997	4.67	-0.08	0.11	-0.03	-0.04	-0.04	9,706	0.46	5.018	0.080	-0.247	-0.022	-0.214	-0.016	14,037	0.63
1998	4.98	-0.13	0.09	-0.03	-0.03	-0.07	12,511	0.44	4.796	0.092	-0.228	-0.017	-0.201	-0.017	13,846	0.62
1999	4.77	-0.08	0.04	-0.04	-0.03	-0.07	11,217	0.50	4.761	0.085	-0.228	-0.020	-0.193	-0.017	13,132	0.66
2000	4.72	-0.07	0.06	-0.03	-0.03	-0.11	11,151	0.50	4.856	0.089	-0.228	-0.026	-0.218	-0.017	12,778	0.66
2001	4.71	-0.08	0.06	-0.04	-0.03	-0.10	14,212	0.59	4.918	0.063	-0.219	-0.029	-0.213	-0.019	12,879	0.66
2002	4.58	-0.03	0.03	-0.03	-0.02	-0.15	15,761	0.53	4.951	0.051	-0.201	-0.037	-0.207	-0.027	10,369	0.67
2003	4.86	-0.06	0.04	-0.02	-0.04	-0.16	18,022	0.54	5.007	0.044	-0.213	-0.037	-0.210	-0.018	9,787	0.70
2004	4.89	-0.05	0.02	-0.03	-0.04	-0.17	18,731	0.51	5.097	0.040	-0.204	-0.048	-0.219	-0.012	9,987	0.69
2005	4.63	-0.04	0.01	-0.04	-0.04	-0.12	20,732	0.55	5.050	0.023	-0.214	-0.038	-0.198	-0.013	12,223	0.72
2006	4.82	-0.04	0.01	-0.04	-0.05	-0.15	20,805	0.58	5.125	0.020	-0.218	-0.046	-0.193	-0.012	12,853	0.71
2007	5.06	-0.07	0.00	-0.03	-0.04	-0.17	19,208	0.62	4.877	0.054	-0.206	-0.041	-0.163	-0.014	13,693	0.74
2008	5.36	-0.08	0.02	-0.04	-0.07	-0.19	16,177	0.61	4.909	0.067	-0.206	-0.053	-0.158	-0.023	14,150	0.72
2009	5.70	-0.20	0.01	-0.04	-0.06	-0.17	14,429	0.63	5.042	0.072	-0.226	-0.055	-0.196	-0.031	10,920	0.72
2010	5.86	-0.22	0.03	-0.04	-0.06	-0.19	14,620	0.63	5.243	0.034	-0.219	-0.042	-0.224	-0.023	15,468	0.72

*The dependent variable in each case is the log price per square meter.

**The table indicate the coefficient of main variables which a part of hedonic estimation results per year.

***Estimation Method: Robust Regression

Table 5: Estimation Results of Hedonic Equations 2

	Published land price model								**Housing rent model**							
Year	Intercept	logL	logW	logA	logTS	logTT	Number	Adj.R^2	Intercept	logS	logA	logTS	logTT	LGT	Number	Adj.R^2
1990	7.83	0.1974	0.40	-	-0.26	-0.99	1,201	0.85	2.83	-0.21	-0.05	-0.03	-0.21	-0.10	33,172	0.71
1991	7.84	0.1993	0.39	-	-0.26	-1.00	1,201	0.85	3.01	-0.22	-0.05	-0.03	-0.21	-0.10	17,622	0.69
1992	7.57	0.1839	0.38	-	-0.24	-0.95	1,202	0.85	3.00	-0.23	-0.06	-0.03	-0.20	-0.08	18,741	0.69
1993	7.14	0.1568	0.31	-	-0.21	-0.88	1,516	0.86	3.03	-0.23	-0.07	-0.03	-0.21	-0.07	22,257	0.70
1994	6.64	0.1297	0.28	-	-0.19	-0.76	1,776	0.86	3.14	-0.21	-0.10	-0.04	-0.22	-0.07	29,477	0.67
1995	6.44	0.1154	0.25	-	-0.17	-0.71	1,969	0.86	3.09	-0.24	-0.06	-0.04	-0.21	-0.04	39,609	0.67
1996	6.24	0.1059	0.22	-	-0.16	-0.66	1,969	0.86	3.05	-0.25	-0.03	-0.04	-0.20	-0.02	56,846	0.67
1997	6.15	0.0897	0.20	-	-0.16	-0.62	1,943	0.87	3.11	-0.27	-0.02	-0.04	-0.21	-0.03	62,482	0.69
1998	6.17	0.0861	0.19	-	-0.16	-0.62	1,944	0.87	3.23	-0.28	-0.03	-0.05	-0.22	-0.04	68,517	0.70
1999	6.22	0.0891	0.17	-	-0.16	-0.64	1,944	0.87	3.24	-0.29	-0.03	-0.04	-0.21	-0.04	73,701	0.71
2000	6.37	0.0931	0.16	-	-0.18	-0.68	1,949	0.87	3.22	-0.30	-0.03	-0.04	-0.21	-0.03	72,248	0.72
2001	6.56	0.0971	0.15	-	-0.19	-0.72	1,951	0.87	3.21	-0.28	-0.03	-0.05	-0.22	-0.02	90,725	0.71
2002	6.72	0.1008	0.14	-	-0.20	-0.75	1,986	0.87	3.18	-0.28	-0.03	-0.05	-0.21	-0.04	98,674	0.73
2003	6.92	0.1034	0.13	-	-0.22	-0.80	1,986	0.87	3.12	-0.28	-0.03	-0.05	-0.21	-0.04	101,845	0.74
2004	7.03	0.1082	0.13	-	-0.23	-0.83	1,984	0.86	3.07	-0.27	-0.03	-0.05	-0.20	-0.04	93,292	0.72
2005	7.15	0.1149	0.13	-	-0.23	-0.86	1,945	0.86	3.02	-0.26	-0.03	-0.05	-0.19	-0.03	82,057	0.71
2006	7.20	0.1227	0.13	-	-0.24	-0.88	1,934	0.86	3.16	-0.27	-0.03	-0.05	-0.22	-0.03	67,287	0.73
2007	7.45	0.1403	0.13	-	-0.25	-0.93	1,856	0.87	3.18	-0.27	-0.03	-0.06	-0.23	-0.02	50,159	0.75
2008	7.68	0.1513	0.14	-	-0.26	-0.96	1,809	0.87	3.16	-0.29	-0.04	-0.05	-0.20	-0.02	35,409	0.76
2009	7.60	0.1582	0.12	-	-0.26	-0.95	1,730	0.86	3.00	-0.30	-0.04	-0.05	-0.16	0.00	21,700	0.76
2010	7.58	0.1454	0.12	-	-0.27	-0.94	1,684	0.86	2.86	-0.31	-0.05	-0.05	-0.13	-0.01	19,258	0.78

*The dependent variable in each case is the log price per square meter.

**The table indicate the coefficient of main variables which a part of hedonic estimation results per year.

***Estimation Method: Robust Regression

1,155,078

the "Age of building (A)," "Distance to nearest station (TS)," and "Travel time to terminal station (TT)" were consistent, so it was determined that we were able to obtain reliable results.

3.3.2 Forecast of Rental Value, Capital Value and Rent / Price ratio

Using the estimated hedonic function, we predicted the rent, housing price, and land price for the various dwelling units for the previously prepared building data. First, we outline the respective changes in average price for the forecast results in Table 6 and Figure1.[18] We calculated the price per 1m for single family house prices and condominium prices and the rent per 1 square meter per year for single family house rents and condominium rents (in Figure 1, 2000 is taken as 1). As well, we calculated the rent/price ratio for each type of dwelling unit and obtained the average value.

Single family house prices and condominium prices peaked in 1990 then reversed direction, whereas rents peaked in 1991 or 1992 before reversing direction. As well, in terms of the extent of the fluctuation, one can see that rents fluctuated less than prices.

These differences in the price changes for both types of housing can also be seen based on changes in the rent/price ratio. The rent/price ratio increased for both from 1990 through 2004. In other words, this means that the rate of decrease for housing prices was faster than the rate of decrease for housing rents.

Subsequently, prices turned to an increase with the occurrence of a mini-bubble while rents continued to decrease steadily, so the rent/price ratio turned to a decrease.

3.3.3 Estimation of Equivalent Rent

Using the estimated hedonic rent function, we calculated the equivalent rent for Tokyo's 23 wards (Table6). In addition to showing the estimated equivalent rent, Table 7 compares it with the GDP, the imputed rent of owner-occupied housing in the GDP, and imputed rent in prefectural accounting.

First, looking at changes in the proportion of the GDP represented by the imputed rent for owner-occupied housing, the rate was 6.25% in 1990, but it has risen significantly over the years to 7.4% in 1995, 8.5% in 2000, 9.08% in 2005, and 9.92% in 2009. In Japan, not only did the proportion of owner-occupied housing rise, but we believe that the relative importance of imputed rent increased due to the accumulation of owned houses as stock that occurred with production and consumption stagnating under deflationary conditions.

When we compare the aggregate imputed rent for owner-occupied housing in prefectural accounting to the imputed rent for owner-occupied housing in national accounting, one can see here that a significant discrepancy exists between the two.

[18] Here, we forecast housing prices and rents using hedonic function estimate values for all periods, based on building stocks in the baseline year of 1990, and then calculated the average value. In other words, it is a weighted average based on 1990 baseline stocks.

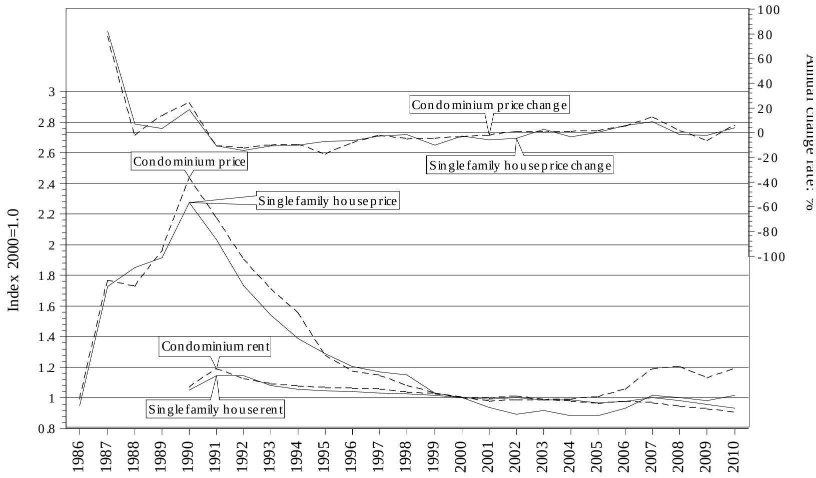

Figure 1: Hedonic Price and Rents Indexes

The imputed rent for owner-occupied housing in national accounting is calculated by multiplying rent unit prices by the total floor space of owner-occupied housing surveyed by the Housing and Land Survey.

On the other hand, in prefectural accounting, imputed rent is calculated as "owner-occupied housing" as part of the breakdown of entrepreneurial income (after receivable and payable of distributed income of corporations). This entrepreneurial income is defined as the presumed real estate income in the hypothetical case where the owner of a home operated a real estate business, and it is calculated by subtracting intermediate input such as repair costs, consumption of fixed capital, taxes such as property tax, interest payments on mortgages, and rent payments from the imputed rent for owner-occupied housing (the revenue).[19]

Here, we compared the equivalent rent estimated from the hedonic rent function estimated in this study to the SNA imputed rent for owner-occupied housing in Tokyo. The discrepancy between the two was especially significant at the bubble's peak in 1990, with an 11-fold discrepancy in 1990 and a 10.5-fold discrepancy in 1991. This discrepancy has grown smaller over the years, contracting to 1.6-fold in 2009.

A more important problem here is that the imputed rent estimated with SNA increased 8.2-fold from 1990 to 2009, whereas the estimated equivalent rent has remained stable, rising 1.18-fold. How can these kinds of differences be explained?

[19] In national accounting as well, under the same definition, "owner-occupied housing" is calculated as part of the breakdown of "entrepreneurial income (after receivable and payable of distributed income of corporations)," with the amount being ¥22.6 trillion in 2009. Even though the definition was the same, there is a discrepancy of ¥4 trillion.

Table 6: Estimation Results of Hedonic Indexes for Housing Prices and Rents

Year	Single family house price (10,000yen/m2)	Condominium price (10,000yen/m2)	Single family house rent (10,000yen/m2)	Condominium rent (10,000yen/m2)	Rent / Price ratio: Single family house(%)	Rent / Price ratio: Condominium (%)
1986	49.48	41.43	-	-	-	-
1987	90.24	73.83	-	-	-	-
1988	96.74	72.05	-	-	-	-
1989	100.03	81.86	-	-	-	-
1990	118.88	101.79	2.70	2.97	2.31%	2.96%
1991	106.19	90.96	2.94	3.28	2.82%	3.68%
1992	90.46	79.64	2.94	3.11	3.32%	3.97%
1993	80.50	71.59	2.77	3.02	3.49%	4.25%
1994	72.43	64.84	2.72	2.98	3.77%	4.62%
1995	67.19	53.41	2.68	2.95	4.02%	5.56%
1996	62.83	48.99	2.67	2.94	4.25%	6.04%
1997	60.97	47.80	2.65	2.92	4.37%	6.15%
1998	60.15	45.19	2.63	2.87	4.41%	6.37%
1999	53.84	43.17	2.62	2.83	4.88%	6.60%
2000	52.20	41.76	2.57	2.76	4.93%	6.65%
2001	48.97	40.85	2.54	2.76	5.21%	6.79%
2002	46.63	41.16	2.58	2.80	5.53%	6.85%
2003	47.81	41.17	2.54	2.74	5.34%	6.70%
2004	46.03	41.43	2.53	2.70	5.54%	6.60%
2005	46.03	42.10	2.49	2.67	5.47%	6.41%
2006	48.77	44.18	2.51	2.71	5.21%	6.22%
2007	53.09	49.60	2.57	2.68	4.93%	5.51%
2008	52.26	50.40	2.52	2.61	4.92%	5.28%
2009	51.21	47.12	2.46	2.57	4.96%	5.56%
2010	53.09	49.67	2.40	2.50	4.73%	5.13%

In terms of the factors causing a more than 10-fold discrepancy at the bubble's peak, it cannot be explained simply by the difference in quality between owner-occupied housing and rented housing that has frequently been pointed out. As well, as seen in Figure 1, rental housing unit prices have been on a downward trend over the years since the bubble's peak. Meanwhile, with respect to owner-occupied housing stock, condominiums increased 2.2-fold from 1990 through 2005, whereas single family houses – which have the most weight – remained stable, increasing 1.2-fold (40% increase in aggregate floor space). Given this context, it is not possible to explain the 8.2-fold increase from 1990 through 2009.

We believe the most important factor giving rise to this kind of discrepancy is that during the bubble period and subsequent collapse period, when the housing market fluctuated significantly, it was not possible to sufficiently link the "paid rent" used in calculating imputed rent to the rent determined by the market, so a significant discrepancy arose between them. This analysis is consistent with the results of Shimizu, Nishimura, and Watanabe (2010). However, even though there was a discrepancy between paid rent and market rent, it cannot explain the problem of a greater than 8-fold expansion from 1990 through 2009.

3.4 Comparison of Imputed Rent of Owner-Occupied Housing in Tokyo

3.4.1 The Treatment of Cost Tied to Owner-Occupied Housing

Next, we will estimate the imputed rent for owner-occupied housing using the User Cost Approach. When attempting to estimate the imputed rent of owner-occupied housing using the User Cost Approach, whether the Basic User Cost Approach, Verbrugge Variant (VV) User Cost Approach, or Diewert's OOH Opportunity Cost Approach, it is necessary to calculate the expense of keeping a home. The expense of keeping a home is comprised of the opportunity cost when viewing the home as a financial asset, property tax arising from keeping a home, damage insurance costs, and maintenance/administration costs. Here, we take into account property tax and maintenance/administration costs.[20]

Financial Opportunity Cost (FOC) In many cases, purchasing a home involves obtaining a mortgage. In this kind of typical case, the Financial Opportunity Cost (FOC) of home ownership is calculated as $r_D^t D^t + r^t(V^t - D^t)$, as shown in Equation7. The FOC in this case is the mortgage payment interest combined with the investment gains that could have been obtained if that money had been invested. Since the mortgage amount is not considered in Equation4 and Equation5, Equation7 is the case where the mortgage is 0. For r_D^t [21], this study used loan interest rates from the former Government Housing Loan

[20] Since damage insurance costs are extremely low, we decided not to consider them in this study.

[21] In recent years, mortgages from private financial institutions have come to be used, but prior to 2000, it was normal to use mortgages from the former Government Housing Loan Corporation. As well, even now, the interest rate set by the Japan Housing Finance Agency is the benchmark for mortgage interest. Given this, we believed that its rates were representative. The average loan interest from the Government Housing Loan Corporation was 0.0527 in 1990, which fluctuated over time to 0.0363 in 1995, 0.0278 in 2000, 0.0308

Corporation (now the Japan Housing Finance Agency) and the yield on 10-year Japanese government bonds for the asset investment yield.[22]

Property Tax It is now supposed that the owner of the housing unit must pay the property taxes T_S^0 and T_L^0 for the use of the structure and land respectively during period 0.[23] Define the period 0 structures tax rate $\tau_S^0$and land tax rate τ_L^0 as follows:

$$\tau_S^0 \equiv T_S^0/P_S^0Q_S^0 \tag{18}$$

$$\tau_L^0 \equiv T_L^0/P_L^0Q_L^0 \tag{19}$$

The new imputed rent for using the property during period 0, R^0, including the property tax costs, is defined as follows:

$$\begin{aligned} R^0 &\equiv V^0(1+r^0) + T_S^0 + T_L^0 - V^{1a} \\ &= [P_S^0Q_S^0 + P_L^0Q_L^0](1+r^0) + \tau_S^0P_S^0Q_S^0 + \tau_L^0P_L^0Q_L^0 - [P_S^0(1+i_S^0)(1-\delta_0)Q_S^0 + P_L^0(1+i_L^0)Q_L^0] \\ &= p_S^0Q_S^0 + p_L^0Q_L^0 \end{aligned} \tag{20}$$

where separate period 0 tax adjusted user costs of structures and land, p_S^0 and p_L^0 , are defined as follows:

$$p_S^0 \equiv [(1+r^0) - (1+i_S^0)(1-\delta_0) + \tau_S^0]P_S^0 = [r^0 - i_S^0 + \delta_0(1+i_S^0) + \tau_S^0]P_S^0 \tag{21}$$

$$p_L^0 \equiv [(1+r^0) - (1+i_L^0) + \tau_L^0]P_L^0 = [r^0 - i_L^0 + \tau_S^0]P_L^0 \tag{22}$$

Here, the question of how P_S^0 or P_L^0 was calculated is important. We estimated P_L^0 with the hedonic function using published land prices that are the benchmark for property tax land evaluation. The estimation results are as shown in Table5.

Using these hedonic function estimation results, we estimated the land evaluation amount by building unit. In addition, we obtained the building price by deducting the land evaluation amount based on the published land price from the estimated total housing price amount.

The nominal property tax rate was 1.4% of the asset amount for both buildings and land. However, the actual effective tax rate is known to be lower than that level. Accordingly, we estimated the effective tax rate for Tokyo.[24]

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in 2005, and 0.0343 in 2010.

[22]The yield on 10-year government bonds from 1990 to 2010 peaked at 0.052 in 1990, dropping to 0.0346 in 1995, 0.0183 in 2000, 0.0140 in 2005, and 0.0117 in 2010. However, throughout the period in question, it may be considered one of the assets that offered the highest return on investment.

[23]If there is no breakdown of the property taxes into structures and land components, then just impute the overall tax into structures and land components based on the beginning of the period values of both components.

[24]In property tax land evaluation, various adjustments are performed, such as relief measures for small-scale residential land. As a result, tax amounts are not necessarily determined based on the land evaluation

Maintenance and Renovation Expenditure Another problem associated with home ownership is the treatment of maintenance expenditures, major repair expenditures and expenditures associated with renovations or additions.

Empirical evidence suggests that the normal decline in a structure due to the effects of aging and use can be offset by maintenance and renovation expenditures. How exactly should these expenditures be treated in the context of modeling the costs and benefits of home ownership?

A common approach in the national accounts literature is to treat major renovation and repair expenditures as capital formation and smaller routine maintenance and repair expenditures as current expenditures.

Accordingly, we calculated annual maintenance/administration costs in this study as well.

Housing maintenance/administration costs may be expected to change in accordance with home size. We therefore calculated maintenance/administration costs per square meter based on a Recruit survey of home buyers, and multiplied this cost by the size (S) of the home. [25]

The values based on this survey are for fiscal 2005 only. We therefore estimated the values for other fiscal years based on the 2005 estimate values and the rate of change for "Repairs & maintenance" in the Tokyo CPI.

3.5 Capital Gain

The most important element in the User Cost Approach is capital gain.

In the Basic User Cost Approach (Equation4), it is defined as $(V_{v+1}^{t+1} - V_v^t)$, which is the price change for each dwelling unit.

However, in the VV User Cost Approach and Diewert's User Cost Approach, it is defined as the expected value for a future period. The reason for this is that it is difficult to assume that in household accounting, the choice of home is made by looking at the price change for a single year and then making an investment, and because the volatility in the actual value of single-year capital gains becomes excessive.

For the present estimate, in the basic model we made the calculation with the actual value of $(V_{v+1}^{t+1} - V_v^t)$ for each dwelling unit.

On the other hand, for the calculation of VV User Cost and Diewert's User Cost, capital gain was obtained as $(\overline{V^{t+1}} - V^t)$. The anticipated growth rate ($E[\pi]$) was obtained as the

amount. Accordingly, we obtained the tax base amount for Tokyo as a whole (the total price determined as the land price for actual taxation purposes) as a proportion of the land asset amount calculated with SNA statistics. The land asset amount calculated with SNA uses published land prices for land price data and uses data adjusted for property taxes for floor space. As a result, both proportions are similar in that they are proportions of the published land price and property tax land evaluation amount.

[25] In Recruit's survey, housing floor space and the actual maintenance/administration costs corresponding to it were surveyed. In the 2005 survey, data was collected for 48,532 condominiums and 23,200 single family houses in Tokyo. Maintenance/administration costs for the 2005 year were ¥3,130 per square meter (annually) for condominiums and ¥920 per square meter (annually) for single family houses. Multiplying these amounts by the average floor space of 60 square meters for condominiums and 100 square meters for single family houses, the annual cost was ¥187,000 for condominiums and ¥92,000 for single family houses.

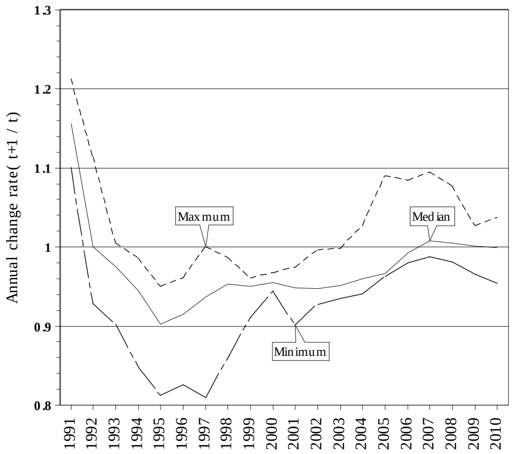

Figure 2: The trend of single family house prices in municipalities

geometric average of the rate of change over the past 5 years by municipality unit (k). [26]

We estimated the price for a future period by multiplying the anticipated growth rate obtained in the above manner by the asset price for each property unit, and obtained the capital gain with

$$(\overline{V^{t+1}} - V^t)$$

Figure2 and Figure3 look at the maximum and minimum values and median value for the anticipated growth rate in municipalities (k). If we compare the average value of the change rate for the actual value(V_{v+1}^{t+1}/V_v^t)(Figure1), the volatility is considerably reduced here.

When looking at the actual value, both single family house prices and condominium prices rose by a maximum of 80% for one year during the bubble period, but when converted into anticipated growth rate, the increase is reduced to around 20%. However, even for the anticipated growth rate, during the time of dramatic price increases in the bubble period, there are municipalities demonstrating a median value of 15% and maximum value of 20% for both single family house prices and condominium prices.

The anticipated growth rate by municipality dropped rapidly due to the bubble's collapse and became negative. It then turned upward again during the so-called mini-bubble of the mid-2000s.

[26]The city of Tokyo was divided into a total of 53 areas: 23 special wards and 30 municipalities. It has become evident that moving to a new location outside of one's administrative district happens very rarely. As well, it is known that housing price changes vary considerably by region. As a result, we deemed it appropriate to calculate anticipated growth rate by administrative district.

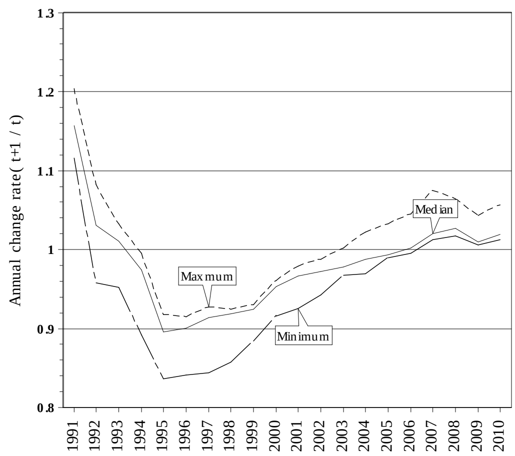

Figure 3: The trend of condominium prices in municipalities

3.6 Comparison of Estimated User Costs

Using the various parameters established as shown above, we obtained the Basic User Cost based on Equation 4, the VV User Cost based on Equation 5, and Diewert's User Cost based on Equation 7. As well, we calculated Diewert's OOH Index taking the maximum value of the results obtained with Diewert's User Cost and Equivalent Rent.

Diewert's OOH Index takes the maximum value when Diewert's User Cost and Equivalent Rent are compared. Figure4 looks at the changes over time in the ratio of Diewert's User Cost > Equivalent Rent for both single family house and condominium prices.

User Cost increases while the anticipated growth rate is decreasing. As a result, in 1992 and 1994 through 1995, periods when the anticipated growth rate dropped considerably, User Cost significantly surpassed Equivalent Rent. On the other hand, in the 2000s, when the rate of decrease in housing prices shrunk and then prices began to turn upward, User Cost decreased. As a result, one can see that the Diewert's User Cost > Equivalent Rent ratio dropped rapidly, and the proportion of Diewert's OOH Index composed by Equivalent Rent grew larger.

The various User Cost estimate results are outlined in Table7, while Figure5 looks at changes in them.In 1991, VV User Cost and Diewert's User Cost were negative. This was due to the residual effect of the dramatic increase in housing prices in the bubble period. On the other hand, since prices turned downward during the one-year period from 1990 to 1991, the Basic User Cost value was extremely high. It was six times higher than Equivalent Rent.

As well, in the mid-2000s, when housing prices turned upward, Basic User Cost had a

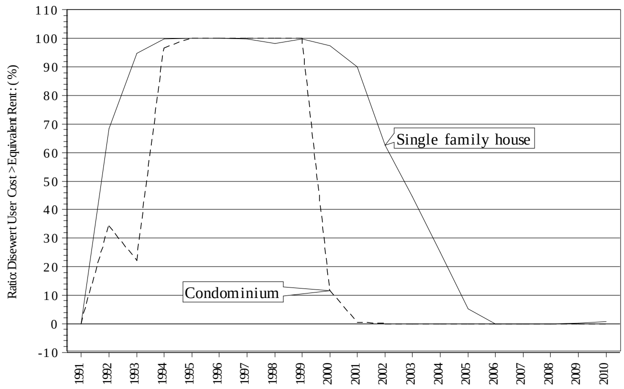

Figure 4: Ratio: Diewert User Cost >Equivalent Rent: (%)

negative value. And for VV User Cost as well, which uses the expected increase rate for housing prices, the value became negative in 2007, at the time of the so-called mini-bubble (Diewert's User Cost was positive).

In order to resolve this kind of problem, employing the maximum value of Equivalent Rent and User Cost in each year for each type of dwelling measurement unit with Diewert's OOH Index has been proposed. For example, in 1991, when User Cost was negative for all dwelling units, since Equivalent Rent was higher for all dwelling units, Diewert's OOH Index is the same as Equivalent Rent. From 1992 through 1995, since capital gain is negative, the weight of User Cost becomes greater. And in 1996, when User Cost exceeded Equivalent Rent for all dwelling units, Diewert's OOH Index is the same as User Cost.

The discrepancy between Diewert's OOH Index and Equivalent Rent becomes greater when the Diewert's User Cost > Equivalent Rent ratio increases. It was greatest in 1995, when a 3.6-fold discrepancy occurred. One can see that it subsequently grew smaller, contracting toward the same level as Equivalent Rent.

4 Concluding Remarks

Having an extremely large weight in national accounting and consumer price statistics, imputed rent for owner-occupied housing plays an important role. It has been pointed out that it is one of the most difficult estimation subjects and various estimation methods have been proposed, but there is still no standardized international approach.

Looking at the case of Tokyo, this study collected as much micro-data as possible and estimated the imputed rent of owner-occupied housing using multiple estimation methods,

Table 7: Estimation results of User Costs

Year	a) Equivalent Rent*	b) Basic User Cost*	c) VV User Cost*	d) Diewert User Cost*	e) Diewert Index*	d) -b)*	d) - c)*	e) - a)*
1991	5,381.91	34,917.15	-17,249.25	-16,969.24	5,381.91	-51,886.39	280.01	0.00
1992	5,283.60	29,172.85	9,414.64	9,141.06	10,419.92	-20,031.78	-273.58	5,136.32
1993	5,021.95	22,840.21	11,742.15	11,524.01	11,589.21	-11,316.20	-218.14	6,567.26
1994	4,933.06	18,828.92	14,916.87	14,639.22	14,639.23	-4,189.69	-277.64	9,706.16
1995	5,268.97	11,404.91	18,786.03	18,624.62	18,886.70	7,219.71	-161.42	13,617.73
1996	5,256.77	8,446.97	16,425.49	16,498.50	16,498.50	8,051.53	73.01	11,241.73
1997	5,219.79	8,231.11	12,849.09	13,223.56	13,223.57	4,992.45	374.47	8,003.78
1998	5,155.46	10,184.68	9,831.25	10,367.09	10,368.52	182.41	535.84	5,213.06
1999	5,157.14	5,429.53	8,858.19	9,112.25	9,127.37	3,682.72	254.06	3,970.22
2000	5,864.61	9,214.74	7,984.24	8,189.68	8,494.76	-1,025.07	205.43	2,630.15
2001	5,831.36	3,620.13	7,063.19	7,673.58	7,729.83	4,053.45	610.39	1,898.46
2002	5,925.69	1,923.76	6,600.24	7,223.75	7,427.48	5,299.99	623.51	1,501.79
2003	5,818.97	4,383.36	5,395.85	6,012.84	6,714.04	1,629.48	617.00	895.07
2004	5,782.20	1,577.33	4,767.56	5,376.14	6,331.98	3,798.81	608.58	549.78
2005	6,001.29	-3,359.14	4,168.27	5,011.60	6,446.76	8,370.73	843.33	445.47
2006	6,062.71	-6,546.35	2,303.28	3,323.47	6,082.47	9,869.83	1,020.20	19.76
2007	6,113.83	6,050.27	-111.39	1,053.99	6,114.15	-4,996.28	1,165.38	0.32
2008	5,951.92	13,441.22	129.20	1,376.28	5,952.16	-12,064.94	1,247.07	0.24
2009	5,815.37	-1,388.15	1,594.28	2,877.89	5,817.18	4,266.04	1,283.61	1.80

*One billion yen

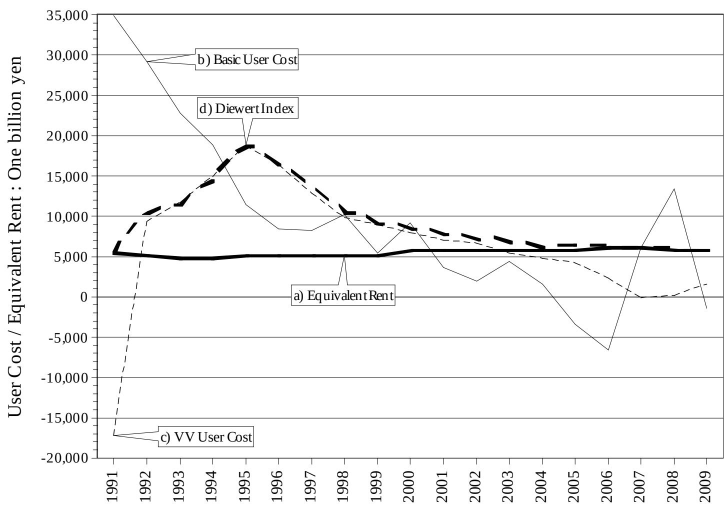

Figure 5: Diewert's OOH Index and User Cost Indexes

with the aim of quantitatively clarifying the extent of the discrepancies that arise due to differences in estimation method.

We started with estimation based on the Equivalent Rent Approach employed in Japan. In this study, for the Equivalent Rent estimation, we calculated a hedonic function using market rent data and obtained the quality-adjusted market rent for each type of dwelling unit.

Looking at the results obtained, at the bubble's peak in 1990, there was an 11-fold discrepancy between the imputed rent of owner-occupied housing calculated in prefectural accounting and the imputed rent estimated here. The divergence between the two then became smaller over the years, shrinking to a 1.6-fold difference in 2009. With regard to the causes of this discrepancy, we have assumed the following.

First, there is the gap in quality between owner-occupied housing and rental housing. In the rent estimated in prefectural accounting, quality adjustment is not performed. But a significant quality gap – such as differences in size – exists between owner-occupied and rental housing. We believe that discrepancies are caused by this quality gap. However, it is not possible to explain the 11-fold difference in scale during the bubble period with the quality gap only. It is assumed that the most significant factor giving rise to the discrepancy between the two sets of results was that during the bubble period and the subsequent collapse, when the housing market fluctuated considerably, it was not possible to sufficiently link the "paid rent" surveyed for the CPI to the market rent, so a significant discrepancy arose between them. The size of this difference was estimated by Shimizu, Nishimura, and Watanabe (2010). However, even though this kind of problem is present, it is not enough to explain the 11-fold difference.

As well, the imputed rent estimated with SNA increased at least 8 times from 1990 to 2009. While the discrepancy between the two shrank over time, during this period rents were on a downward trend and the increase in owner-occupied housing stocks was stable at around 40%. This kind of change is impossible to explain, and one has to think that there is a major problem with the estimation method.

Next, we estimated imputed rent based on the User Cost Approach. Even though market rent was used in the Equivalent Rent estimation, it was easy to predict that it would be difficult to sensitively capture fluctuations during the period when housing prices changed dramatically. While estimation with the User Cost Approach has been proposed in this kind of situation, problems have been pointed out with the conventional Basic User Cost Approach: the User Cost becomes negative when there are major increases in housing prices, and it rises significantly during large-scale downward phases such as immediately after the bubble's collapse. In other words, the volatility exceeds what is expected by market players.

Accordingly, we estimated the VV User Cost proposed by Ptacek and Verbrugge (2005) and Diewert's User Cost and Diewert's OOH Index proposed by Diewert and Nakamura (2009),(2011).

Looking at the estimate results, a significant gap arises between the Basic User Cost and the VV User Cost and Diewert's User Cost at the start of the bubble collapse period in 1991.

The bubble collapsed in 1990, and as prices dropped through 1991, the rise in the Basic User Cost was 6 times greater than that for Equivalent Rent. Meanwhile, with the VV User Cost and Diewert's User Cost, which calculated capital gain using the anticipated growth rate for housing prices by municipality over the previous 5 years, the User Cost became negative.

Even if the capital gain calculation is converted into the anticipated growth rate for the previous 5 years in order to assimilate the dramatic single-year price change, the User Cost becomes negative.

The reason for this is that the dramatic increase in housing prices during the bubble period has a residual effect on the anticipated growth rate. What's more, the Basic User Cost has a negative value during the market recovery period in the 2000s as well, and the VV User Cost also becomes negative in 2007 during the so-called mini-bubble.

This shows that even when capital gain is calculated as the anticipated growth rate, the User Cost becomes negative during large-scale price fluctuations such as the real estate bubble that occurred in 1980s' Tokyo or amid significant changes in market prices such as the "mini-bubble."

In order to resolve this kind of problem, employing the maximum value of Equivalent Rent and User Cost for each dwelling measurement unit with Diewert's OOH Index has been proposed. Looking at the difference between Diewert's OOH Index estimated in this manner and Equivalent Rent reveals that a 3.5-fold discrepancy occurred in 1995 and that there was on average an around 1.7-fold discrepancy from 1990 through 2009.

These findings show that even if Equivalent Rent approach is improved, quality adjustment is performed, and market rent is used, significant discrepancies remain between the estimation methods.

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