

# Measuring the Services of Durables and Owner Occupied Housing.

Dec 25, 2018

Ministry of Internal Affairs and Communications, Tokyo

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# 1. Introduction.

- This paper provides an update to the chapter on **the treatment of durables in the Consumer Price Index Manual (2004)**. The most important durable is housing, which typically accounts for approximately 20% of total consumption services. A large fraction of total housing services consists of the services of Owner Occupied Housing (OOH).
- The main approaches to measuring the services of OOH are **(i) the acquisitions approach; (ii) the rental equivalence approach and (iii) the user cost approach**. Two other approaches are sometimes used: (iv) the opportunity cost approach and (v) the payments approach.
- A main purpose of this paper is to present the main approaches to the treatment of OOH and to discuss the benefits and costs of the alternative approaches.

## Introduction (cont)

- When a durable good (other than housing) is purchased by a consumer, national Consumer Price Indexes typically attribute all of that expenditure to the period of purchase, even though the use of the good extends beyond the period of purchase.
- → **Acquisitions approach**
- However, if one takes a cost of living approach to the Consumer Price Index, then it may be more appropriate to take the cost of using the services of the durable good during the period under consideration as the pricing concept.
- → **Rental equivalence approach.**
- → **User cost approach.**

## **Rental equivalence approach & User cost approach.**

- **Rental equivalence approach.**
  - If rental or leasing markets for a comparable consumer durable exist, then this market rental price could be used as an estimate for the cost of using the durable during the period.
- **User cost approach.**
  - If used or second hand markets for the durable exist, then the imputed cost of purchasing a durable good at the beginning of the period and selling it at the end could be computed and this net cost could be used as a estimate for the cost of using the durable during the period.

## The major *advantages* and *disadvantages* of the acquisitions approach.

- *Advantages:*
  - It is conceptually simple and entirely similar to the treatment of nondurables and services and
  - No complex imputations are required.
- *Disadvantages:*
  - The acquisitions approach is not likely to reflect accurately the consumption services of consumer durables in any period. Thus suppose that real interest rates in a country are very high due to a macroeconomic crisis. **Under these conditions, purchases of automobiles and houses and other long lived consumer durables may drop dramatically, perhaps to zero.** However, the actual consumption of automobile and housing services of the country's population will not fall to zero under these circumstances: households will still be consuming the services of their existing stocks of motor vehicles and houses.

## The fundamental problem of accounting.

- *“Durability means that a capital good is productive for two or more time periods, and this, in turn, implies that a distinction must be made between the value of using or renting capital in any year and the value of owning the capital asset. This distinction would not necessarily lead to a measurement problem if the capital services used in any given year were paid for in that year; that is, if all capital were rented. In this case, transactions in the rental market would fix the price and quantity of capital in each time period, much as data on the price and quantity of labor services are derived from labor market transactions. But, unfortunately, much capital is utilized by its owner and the transfer of capital services between owner and user results in an implicit rent typically not observed by the statistician. Market data are thus inadequate for the task of directly estimating the price and quantity of capital services, and this has led to the development of indirect procedures for inferring the quantity of capital, like the perpetual inventory method, or to the acceptance of flawed measures, like book value.” Charles R. Hulten (1990; 120-121).*

## Three major methods.

- **Acquisition Approach.**
  - Ignore the problem of distributing the initial cost of the durable over the useful life of the good and allocate the entire charge to the period of purchase. As noted above, this is known as the *acquisitions approach* and it is the present approach used by Consumer Price Index statisticians for all durables with the exception of housing.
- **Rental Equivalent Approach.**
  - The *rental equivalence approach*. In this approach, a period price is imputed for the durable which is equal to the rental price or leasing price of an equivalent consumer durable for the same period of time.
- **User Cost Approach.**
  - The *user cost approach*. In this approach, the initial purchase cost of the durable is decomposed into two parts: one part which reflects **an estimated cost of using the services** of the durable for the period and another part, which is regarded as an investment, which must earn **some exogenous rate of return**.

## 2. The Acquisitions Approach.

- Thus the weights for the *net acquisitions approach* are the *net purchases of the household sector of houses* from other institutional sectors in the base period.
- “The first is the net acquisition approach, which is the change in the price of newly purchased owner occupied dwellings, *weighted by the net purchases of the reference population*. This is an asset based measure, and therefore comes close to my preferred measure of inflation as a change in the value of money, though the change in the price of the stock of existing houses rather than just of net purchases would in some respects be even better. It is, moreover, consistent with the treatment of other durables. A few countries, e.g., Australia and New Zealand, have used it, and it is, I understand, the main contender for use in the Euro-area Harmonized Index of Consumer Prices (HICP), which currently excludes any measure of the purchase price of (new) housing, though it does include minor repairs and maintenance by home owners, as well as all expenditures by tenants.” Charles Goodhart (2001; F350).



## Problems in acquisition approach.

- If the base year corresponds to a boom year (or a slump year) for the durable, then the base period expenditure weights may be too large or too small. Put another way, the aggregate expenditures that correspond to the acquisitions approach are likely to be **more volatile than the expenditures for the aggregate that are implied by the rental equivalence or user cost approaches.**
- In making comparisons of consumption across countries where **the proportion of owning versus renting or leasing the durable varies greatly, the use of the acquisitions approach may lead to misleading cross country comparisons.** The reason for this is that opportunity costs of capital are excluded in the net acquisitions approach whereas they are explicitly or implicitly included in the other two approaches.

## Fundamental View.

- More fundamentally, whether the acquisitions approach is the right one or not depends on the overall purpose of the index number.
- If the purpose is to measure the price of current period *consumption services*, then the acquisitions approach can only be regarded as an approximation to a more appropriate approach (which would be either the rental equivalence or user cost approach).
- If the purpose of the index is to measure *monetary (or nonimputed) expenditures by households during the period*, then the acquisitions approach might be preferable (provided the land component of property value is in scope), since the rental equivalence and user cost approaches necessarily involve imputations.

## Discussion in Eurostat.

- The details of the acquisitions approach (as applied to OOH) are discussed in great detail in Eurostat (2017). Eurostat is considering the use of the acquisitions approach for the treatment of OOH in its Harmonized Index of Consumer Prices (HICP) but at this date, no decision has been finalized.
- At present, OOH is simply omitted in the HICP. Eurostat is considering the use of the acquisitions approach for OOH because at first sight, it seems that no imputations have to be made in order to implement it. The HICP was created as an index of consumer prices that used actual transactions prices without the use of any imputations. As such, it was thought to be particularly useful for monitoring inflation by central banks.
- However, the sale of a newly constructed dwelling unit typically includes a land component which Eurostat wants to exclude but existing methods for excluding the land component involve imputations.

### 3. The Rental Equivalence Approach.

- The *rental equivalence approach* simply values the services yielded by the use of a consumer durable good for a period by the corresponding market rental value for the same durable for the same period of time (if such a rental value exists). This is the approach taken in the *System of National Accounts: 1993* and Eurostat: 2001 for owner occupied housing:
  - “As well-organized markets for rented housing exist in most countries, the output of own-account housing services can be **valued using the prices of the same kinds of services** sold on the market with the general valuation rules adopted for goods and services produced on own account. In other words, the output of housing services produced by owner-occupiers is valued at the estimated rental that a tenant would pay for the same accommodation, **taking into account factors such as location, neighbourhood amenities, etc. as well as the size and quality of the dwelling itself.**” Eurostat, IMF, OECD, UN and World Bank (1993; 134).
  - “The output of dwelling services of owner occupiers at current prices is in many countries estimated by linking the actual rents paid by those renting similar properties in the rented sector to those of owner occupiers. **This allows the imputation of a notional rent for the service owner occupiers receive from their property.**” Eurostat (2001; 99).

# The statistical agency find the relevant rental data to price the services of OOH

- Ask home owners what **they think the market rent** for their dwelling unit is;
- Undertake a survey of owners of rental properties or managers of rental properties and **ask what rents they charge for their rental properties** by type of property or
- Use one of the above two methods to get **a rent to value ratio for various types of property for a benchmark period** and then link these ratios to indexes of purchase prices for the various types of property.

## Disadvantages in Rental Equivalence Approach.

- Homeowners may not be able to provide very accurate estimates for the rental value of their dwelling unit.
- On the other hand, if the statistical agency tries to match the characteristics of an owned dwelling unit with a comparable unit that is rented in order to obtain the imputed rent for the owned unit, **there may be difficulties in finding such comparable units. Furthermore, even if a comparable unit is found, the rent for the comparable unit may not be an appropriate opportunity cost for valuing the services of the owned unit.**
- The statistical agency should make **an adjustment to these estimated rents over time in order to take into account the effects of *depreciation*, which causes the quality of the unit to slowly decline over time** (unless this effect is completely offset by renovation and repair expenditures).
- Care must be taken to determine exactly what extra services are included in the homeowner's estimated rent; i.e., does **the rent include insurance, electricity and fuel or the use of various consumer durables in addition to the structure?** If so, these extra services should be stripped out of the rent, if they are covered elsewhere in the consumer price index.

## Case of Japan.

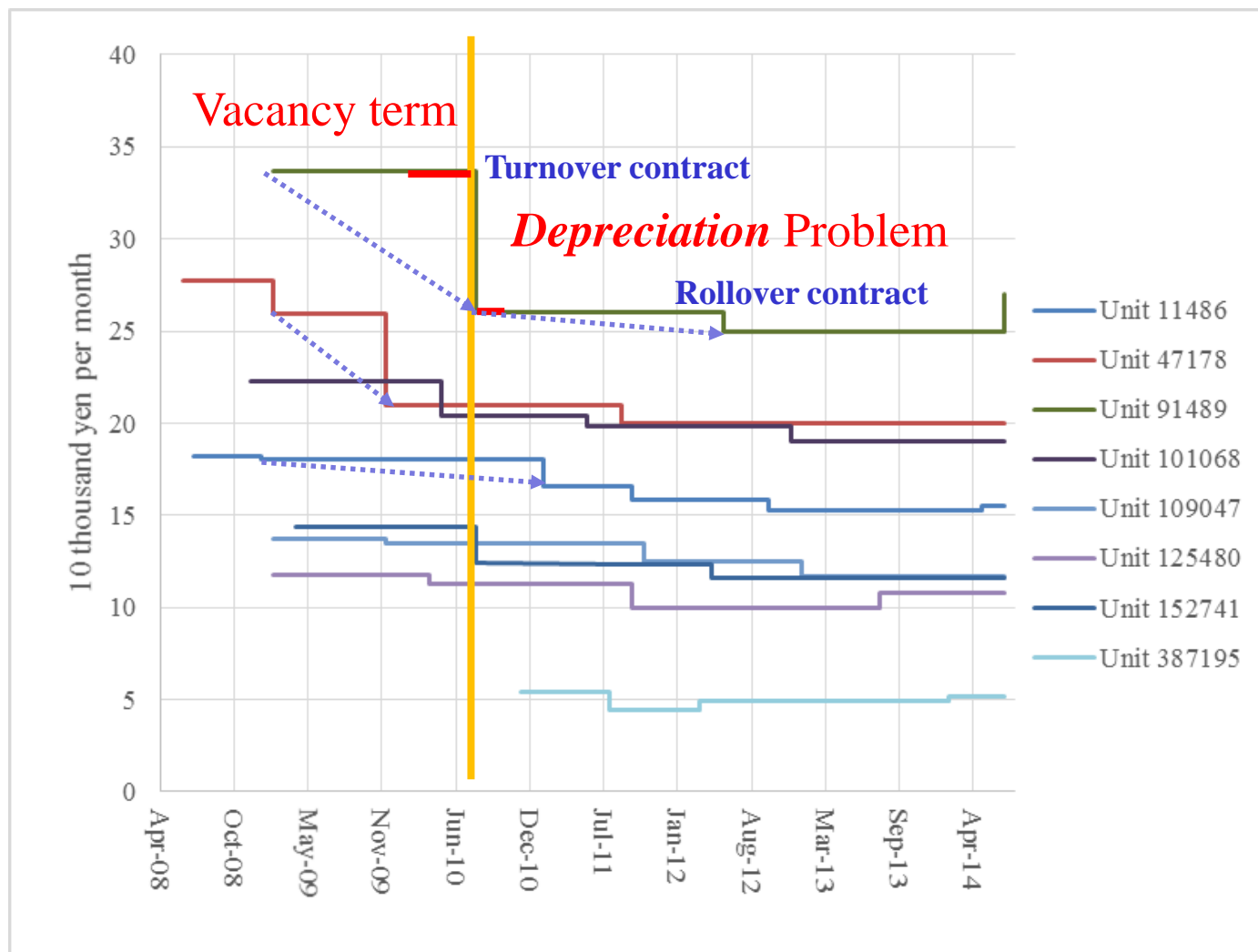
- In order to overcome the first difficulty listed above, statistical agencies, including the Japanese government, are currently collecting housing rent data from property management companies or owners who rent out their dwelling units; i.e.,
- Japan uses the second method to value the services of OOH. However, the characteristics of the owner occupied population of dwelling units are generally quite different from the characteristics of the rental population.
- Thus typically, it is difficult to find rental units that are comparable to owned dwelling units. The use of hedonic regression techniques can mitigate this lack of matching problem. Moreover the use of hedonic regressions can deal with the **depreciation or quality decline problem** mentioned above.

## Newly signed rental contracts and rollover contracts.

- The rents used to estimate the cost of rented dwellings in the Japanese CPI is the aggregate of rents paid for rental accommodation. These rents include a combination of newly signed rental contracts and rollover contracts for existing tenants.
- It is appropriate to use both types of contract to measure the actual cost of rental housing (but of course, these rents should be quality adjusted for depreciation and other changes in quality).
- But it is not appropriate to use both types of contract to impute rents for owner occupied housing: only market rents should be used. It is known that price adjustments are basically not made for rollover contracts (i.e. renewed leases). As a result, it is to be expected that new contract rents determined freely by the market will diverge considerably from rollover contract rents.
- Genesove (2003), Shimizu, Nishimura and Watanabe (2010b), Shimizu and Watanabe (2011) .



# Profile of units.(using paying rent)



## 4. The User Cost Approach for Pricing the Services of a Non-Housing Durable Good.

- The user cost approach to the treatment of durable goods is in some ways very simple: **it calculates the cost of purchasing the durable at the beginning of the period**, using the services of the durable during the period and then netting off from these costs the benefit that could **be obtained by selling the durable good at the end of the period**.
- However, there are several details of this procedure that are somewhat controversial. These details involve the use of opportunity costs, which are usually imputed costs, the treatment of interest and the treatment of **capital gains** or holding gains.
- Typically, when constructing a consumer price index, we think of all quantity purchases as taking place at a single point in time, say the middle of the period under consideration, at the (unit value) average prices for the period. In constructing user costs, **prices at the beginning and end of an accounting period play an important role**.

## Formula of User Cost.

- To determine the net cost of using a durable good during say period 0, it is assumed that one unit of the durable good is purchased at the beginning of period 0 at the price  $P^0$ . The “used” or “second-hand” durable good can be sold at the end of period 0 at the price  $PS^1$ . It might seem that a reasonable net cost for the use of one unit of the consumer durable during period 0 is its initial purchase price  $P^0$  less its end of period 0 “**scrap value**”,  $PS^1$ .
- However, **money received at the end of the period is not as valuable as money that is received at the beginning of the period**. Thus in order to convert the end of period value into its beginning of the period equivalent value, it is necessary to discount the term  $PS^1$  by the term  $1+r^0$  where  $r^0$  is the beginning of period 0 nominal interest rate that the consumer faces.
- Hence the period 0 user cost  $u^0$  for the consumer durable is defined as:
- **(1)  $u^0 = P^0 + PS^1/(1+r^0)$ .**

## Formula of User Cost.(cont)

- There is another way to view the user cost formula (1): the consumer purchases the durable at the beginning of period 0 at the price  $P^0$  and charges himself or herself the rental price  $u^0$ . The remainder of the purchase price,  $I^0$ , defined as:
  - **(2)  $I^0 \equiv P^0 - u^0$**
  - can be regarded as an *investment*, which is to yield the appropriate opportunity cost of capital  $r^0$  that the consumer faces. At the end of period 0, this rate of return could be realized provided that  $I^0$ ,  $r^0$  and the selling price of the durable at the end of the period  $P_S^1$  satisfy the following equation:
    - **(3)  $I^0(1+r^0) = P_S^1$  .**
    - Given  $P_S^1$  and  $r^0$ , (3) determines  $I^0$ , which in turn, given  $P^0$ , determines the user cost  $u^0$  via (2).

## Formula of User Cost.(cont)

- The user cost formula (1) can be put into a more familiar form if the period 0 *economic depreciation rate*  $\delta$  and the period 0 *ex post asset inflation rate*  $i^0$  are defined. Define  $\delta$  by:
  - **(4)  $(1 - \delta) \equiv P_S^1/P^1$**
  - where  $P_S^1$  is the price of a one period old used asset at the end of period 0 and  $P^1$  is the price of a new asset at the end of period 0. Typically, if a new asset and a one period older asset are sold at the same time, then the new asset will be worth more than the used asset and hence  $\delta$  will be a positive number between 0 and 1. The *period 0 inflation rate* for the new asset,  $i^0$ , is defined by:
    - **(5)  $1+i^0 \equiv P^1/P^0$  .**
    - Eliminating  $P^1$  from equations (4) and (5) leads to the following formula for the *end of period 0 used asset price*:
    - **(6)  $P_S^1 = (1 - \delta)(1 + i^0)P^0$  .**

## Formula of User Cost.(cont)

- Substitution of (6) into (1) yields the following expression for the *period 0 user cost*  $u^0$ :
- **(7)**  $u^0 = [(1 + r^0) - (1 - \delta)(1 + i^0)]P^0 / (1 + r^0)$  .
- Note that  $r^0 - i^0$  can be interpreted as a period 0 *real interest rate* and  $\delta(1+i^0)$  can be interpreted as an *inflation adjusted depreciation rate*.
- The user cost  $u^0$  is expressed in terms of prices that are discounted to the *beginning* of period 0. However, it is also possible to express the user cost in terms of prices that are “anti-discounted” or *appreciated* to the *end* of period 0. Thus define the *end of period 0 user cost*  $p^0$  as:
- **(8)**  $p^0 \equiv (1 + r^0)u^0 = [(1 + r^0) - (1 - \delta)(1 + i^0)]P^0$
- where the last equation follows using (7). If the real interest rate  $r^{0*}$  is defined as the nominal interest rate  $r^0$  less the asset inflation rate  $i^0$  and the small term  $\delta i^0$  is neglected, then the end of the period user cost defined by (8) reduces to:
- **(9)**  $p^0 = (r^{0*} + \delta)P^0$  .

## Calculation of User Cost.

- Abstracting from transactions costs and inflation, it can be seen that the end of the period user cost defined by (9) is an *approximate rental cost*; i.e., the rental cost for the use of a consumer (or producer) durable good should equal **the (real) opportunity cost of the capital tied up,  $r^0 \cdot P^0$ , plus the decline in value of the asset over the period,  $\delta P^0$ .**
- Formulae (8) and (9) thus cast some light on what are the economic determinants of rental or leasing prices for consumer durables.

## Calculation of User Cost.(cont)

- If the simplified user cost formula defined by (9) above is used, then at first glance, forming a price index for the user cost of a durable good is not very much more difficult than forming a price index for the purchase price of the durable good,  $P^0$ . The price statistician needs only to:
  - Make a reasonable assumption as to what an **appropriate monthly or quarterly real interest rate  $r^{0*}$**  should be;
  - Make an assumption as to what a reasonable **monthly or quarterly depreciation rate  $\delta$**  should be;
  - **Collect purchase prices  $P^0$**  for the durable and use formula (9) to calculate the simplified user cost.



## The entire user cost formula.

- If it is thought necessary to implement the more complicated user cost formula (8) in place of the simpler formula (9), then the situation is more complicated. As it stands, the end of the period user cost formula (8) is an *ex post* (or after the fact) *user cost*: the asset inflation rate  $i^0$  cannot be calculated until the end of period 0 has been reached. Formula (8) can be converted into an *ex ante* (or before the fact) *user cost* formula if  $i^0$  is interpreted as an *anticipated asset inflation rate*. The resulting formula should approximate a market rental rate for the durable good.
- Note that in the user cost approach to the treatment of consumer durables, the *entire* user cost formula (8) or (9) is the period 0 price. Thus in the time series context, it is *not* necessary to deflate each component of the formula *separately*; the period 0 price  $p^0 \equiv [r^0 - i^0 + \delta(1+i^0)]P^0$  is compared to the corresponding period 1 price,  $p^1 \equiv [r^1 - i^1 + \delta(1+i^1)]P^1$  and so on.
- In principle, depreciation rates can be estimated using information on the selling prices of used units of the durable good. **However, for housing, the situation is more complex.**

## 5. The Opportunity Cost Approach.

- The opportunity cost approach to the valuation of the services of a consumer durable during a time period is very easy to describe: **the opportunity cost valuation is simply the *maximum* of the foregone rental or leasing price for the services of the durable during a period of time and the corresponding user cost for the durable.**
- It is easy to see that when a household has a consumer durable in its possession, the household forgoes the money that one could earn by renting out the services of the durable good for the period of time under consideration. (Such rental markets may not exist, in which case, this opportunity cost is 0).
- However, there is another opportunity cost that is applicable to using the services of the durable good during the period under consideration.

## Opportunity Cost Approach.

- The term opportunity cost refers to the cost of the best alternative that must *be forgone in taking the option chosen.*
- **Option0**: Homeowner continue to live the home.
- → Opportunity Cost associated with **Option0**.
- **Option1**: Selling at the beginning of period  $t$  and buy back at the  $t+1$  .→ **User Cost.**
- **Option2**: Renting out from  $t$  to  $t+1$ . → **Equivalent Rent.**

- $t+0$ , **Option1 (User Cost) > Option2 (E. Rent) = Option1**
- $t+1$ , **Option1 (User Cost) < Option2 (E. Rent) = Option2**

## 6. The Payments Approach.

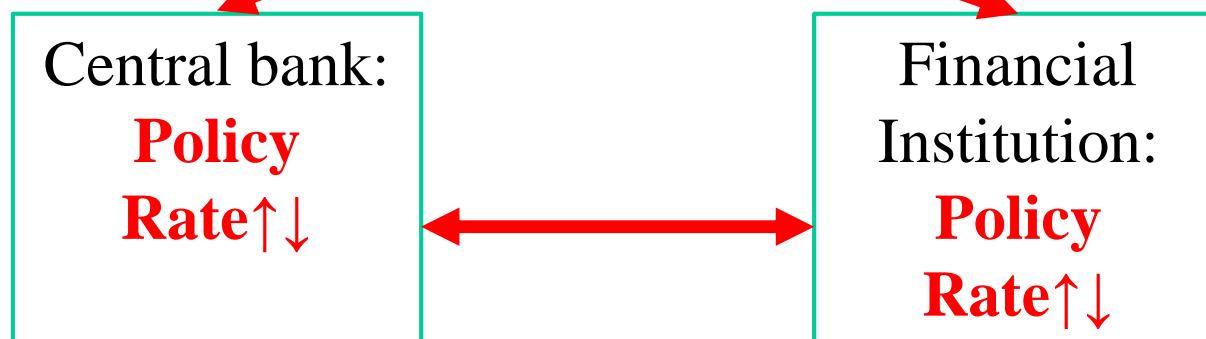
- The fifth possible approach to the treatment of owner occupied housing in a CPI, the *payments approach*, is described by Goodhart as follows:
  - 
  - “The second main approach is the payments approach, **measuring actual cash outflows, on down payments, mortgage repayments and mortgage interest, or some subset of the above.** ... Despite its problems, such a cash payment approach was used in the United Kingdom until 1994 and still is in Ireland.” Charles Goodhart (2001; F350-F351).
  -
- Thus the *payments approach* to owner occupied housing is a kind of a *cash flow approach* to the costs of operating an owner occupied dwelling. It consists mainly of mortgage interest and principle payments along with property taxes. Imputations for capital gains, for the cost of capital tied up in house equity and depreciation are ignored in this approach.

## The Payments Approach.(cont)

- This leads to the following objections to this approach; i.e., it ignores the opportunity costs of holding the equity in the owner occupied dwelling, it **ignores depreciation and it uses nominal interest rates** without any offset for inflation in the price of land and the structure.
- In general, the payments approach will tend to lead to much smaller monthly expenditures on owner occupied housing than the other 4 main approaches, except during periods of high inflation, when the nominal mortgage rate term may become very large without any offsetting item for inflation.
- One reason for implementing this approach is that it may be useful for indexing the pensions of homeowners; i.e., as the cash costs of home ownership increase, it may be popular to increase pensions to offset these costs. This line of argument has some validity but in recent years, perhaps it is less compelling in many countries due to the ability of homeowners to draw on their equity with reverse mortgages and to postpone paying property taxes until the property is sold.

## Vicious circle in Financial Policy.

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



**UK experience: CPI included  
Mortgage rate**

## 7. Residential Property Price Index.

- Hedonic Model (pooling data)**

$$\ln P_{it} = \alpha + \ln x'_i \beta + \mathbf{d}'_i \delta + v_{it}$$

$$\mathbf{d}_i = \{d_{i2}, d_{i3}, \dots, d_{it}, \dots\} \quad \text{Time dummy variable}$$

$$\delta = \{\delta_2, \delta_3, \dots, \delta_t, \dots\} \quad \text{Time effect}$$

- Repeat Sales Model**

- (Bailey, Muth and Nourse 1963 A.S.A.J;  $RS_{RMN}$ )  $\rightarrow$  Log difference of 2<sup>nd</sup> sale prices and 1<sup>st</sup> sale prices

$$d_{iu} = \begin{cases} 1 & u = t \\ 0 & u \neq t \end{cases} \quad v_{it} \sim NID(0, \sigma_v^2)$$

$$\ln (P_{it}/P_{is}) = \Delta_{ts} \ln P_i = \mathbf{D}'_i \delta + v_{its}$$

$$D_{iu} = \begin{cases} -1 & u = s & \text{1st sale} \\ 1 & u = t & \text{2nd sale} \\ 0 & \text{otherwise} & v_{its} = v_{it} - v_{is} \end{cases}$$



# Property Price Transaction Samples

$P_{i,t}$  : property  $i$ , transaction time  $t$ , \*Repeat Sales Samples

Time										
	1	2	3	4	5	6	7	8	9	10
1*	$P_{1,1}$			$P_{1,4}$					$P_{1,9}$	
2								$P_{2,8}$		
3*		$P_{3,2}$		$P_{3,4}$			$P_{3,7}$			$P_{3,10}$
4						$P_{4,6}$				
5		$P_{5,2}$								
6					$P_{6,5}$					
7*			$P_{7,3}$				$P_{7,7}$			
8				$P_{8,4}$						
• • •	•	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •
n*								$P_{n,8}$		$P_{n,10}$



## Disadvantages: Repeat Sales Method and Hedonic Method

- **Hedonic Method:**

- -not all the information that make up property prices is observable; as a result, it has been noted that *“omitted variable bias”* occurs.

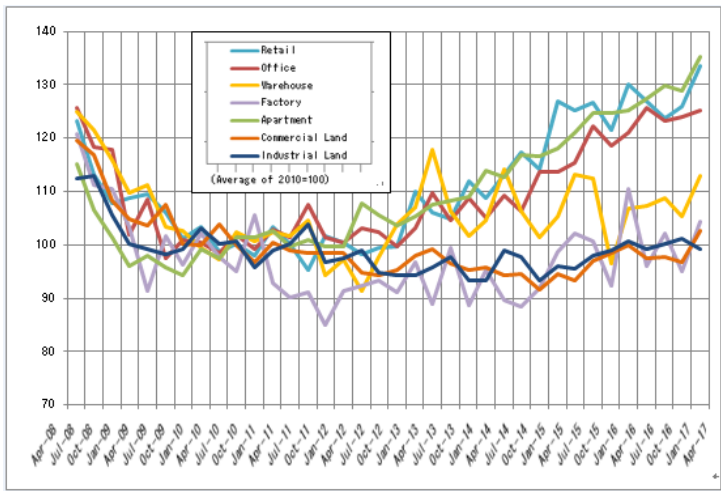
- **Repeat Sales Method:**

- - there is sample selection bias (Clapp and Giaccotto 1992);
- - the assumption **that there are no changes in property characteristics and their parameters during the transaction period is unrealistic** (Case and Shiller,1987, 1989; Clapp and Giaccotto, 1992, 1998, 1999; Goodman and Thibodeau,1998; Case et al. 1991).
- *→Depreciation Problem*
- *→Renovation Problem*
- By Diewert, W. Erwin E.(2007), “The Paris OECD-IMF Workshop on Real Estate Price Indexes: Conclusions and Future Directions,” The University of British Columbia, Department of Economics, Discussion Paper 07-01.

# Figures of JRPPi and JCPPI

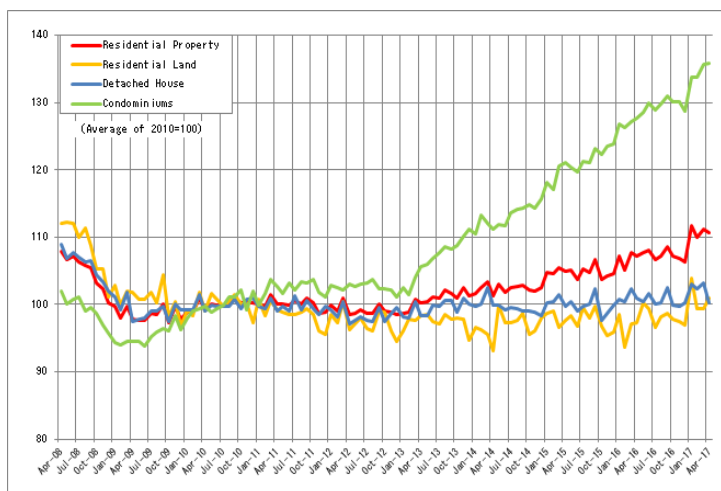
## JCPPI

【Nationwide (since April 2008)】

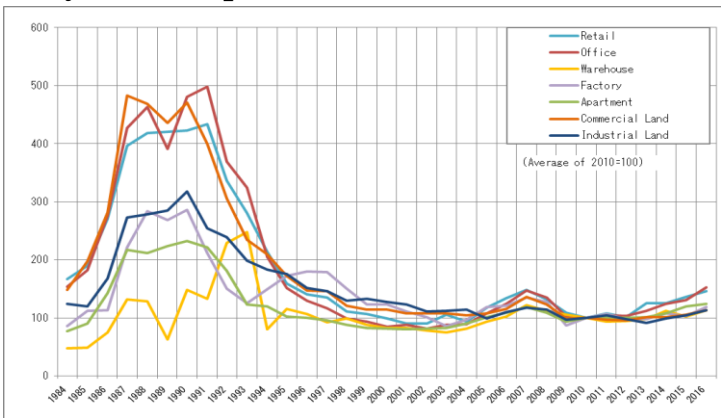


## JRPPi

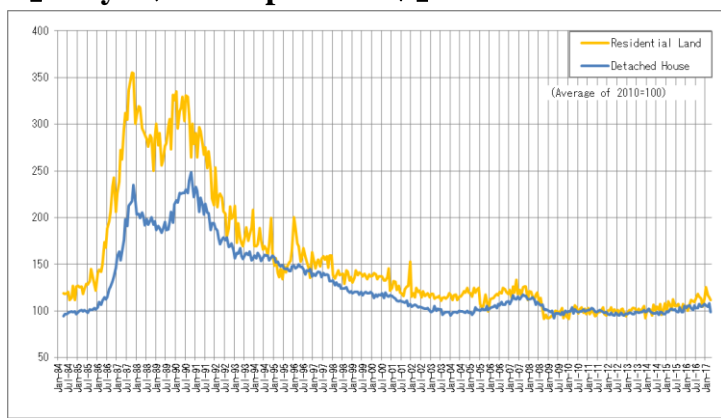
【Nationwide (since April 2007)】



【Tokyo (since April 1984)】(※)



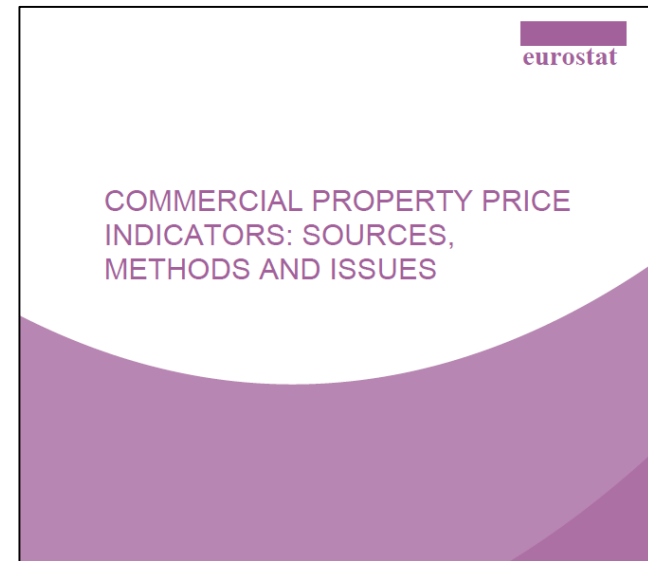
【Tokyo (since April 1984)】



(※) Figures of JCPPI and JRPPi before March 2008 are calculated in cooperation with Tokyo Association of Real Estate Appraisers.

## 8. Alternative model for *depreciation rate*.

- A General Model of Depreciation for (Unchanging) Consumer Durables.
- Geometric or Declining Balance Depreciation.
- Straight Line Depreciation.
- One Hoss Shay or Light Bulb Depreciation.



## Builder's Model.

- Assume that these prices are equal to the sum of the land and structure costs plus error terms  $\varepsilon_{tn}$  which we assume are independently normally distributed with zero means and constant variances. This leads to the following **hedonic regression model** for period  $t$  where the  $\alpha_t$  and  $\beta_t$  are the parameters to be estimated in the regression:

$$(1) \quad V_{tn} = \alpha_t L_{tn} + \beta_t S_{tn} + \varepsilon_{tn};$$

$$t = 1, \dots, T; n = 1, \dots, N(t).$$

- Note that the two characteristics in our simple model are the quantities of land  $L_{tn}$  and the quantities of structure floor space  $S_{tn}$  associated with property  $n$  in period  $t$  and the two **constant quality prices** in period  $t$  are the price of a square meter of land  $\alpha_t$  and the price of a square meter of structure floor space  $\beta_t$ .

## The Builder's Model Using MLIT Data (cont.)

- The hedonic regression model defined by (1) applies to new structures. But it is likely that a model that is similar to (1) applies to older structures as well. Older structures will be worth less than newer structures due to the depreciation of the structure.
- Assuming that we have information on the *age of the structure*  $n$  at time  $t$ , say  $\mathbf{A}(t,n)$ , and assuming a geometric (or declining balance) depreciation model, a more realistic model is the following **basic builder's model**:

$$(2) V_{tn} = \alpha_t L_{tn} + \beta_t (1 - \delta)^{A(t,n)} S_{tn} + \varepsilon_{tn} ; \quad t = 1, \dots, T; \quad n = 1, \dots, N(t)$$

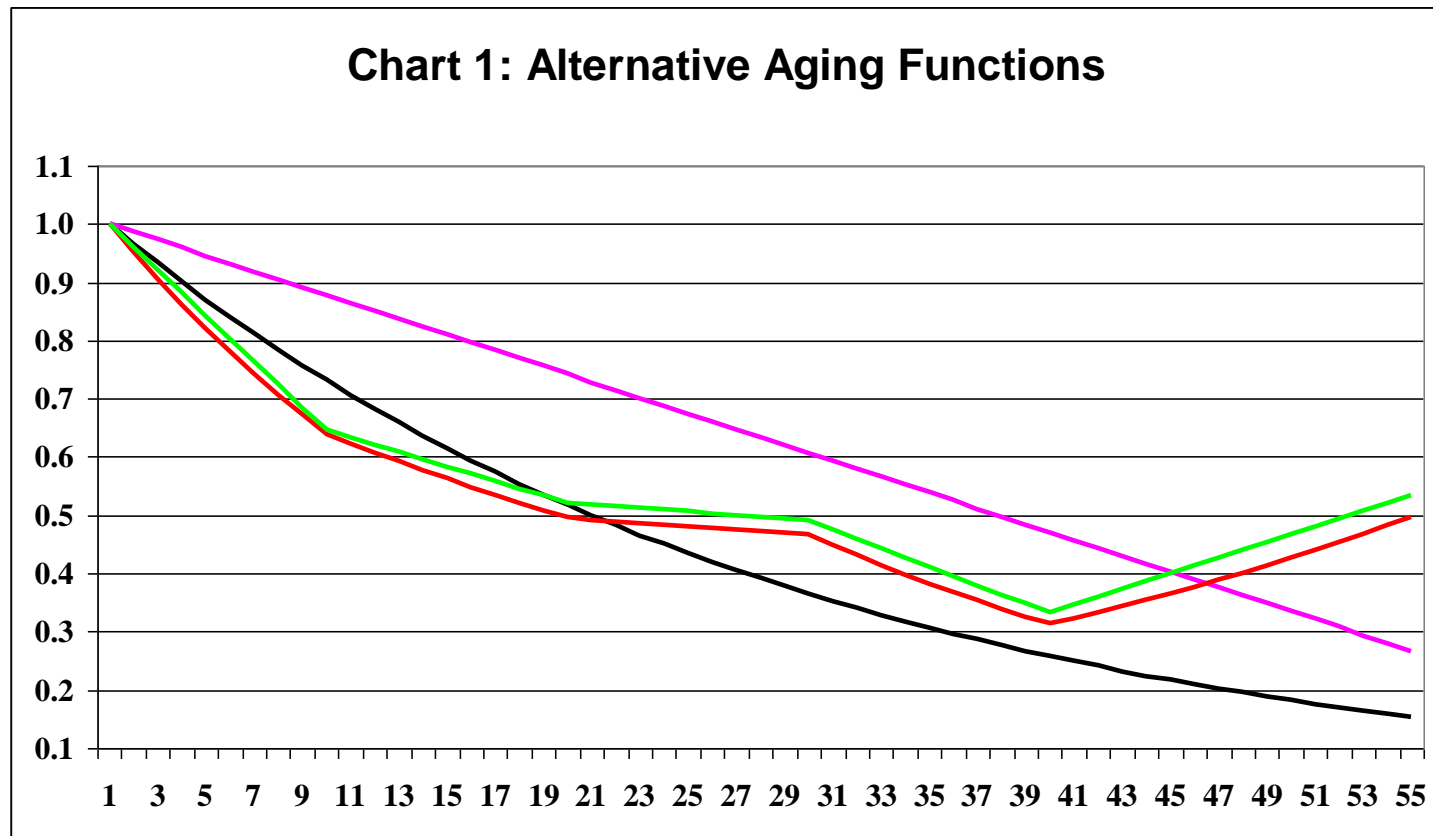
- where the parameter  $\delta$  reflects the **net geometric depreciation rate** as the structure ages one additional period.

## The Builder's Model. Depreciation.

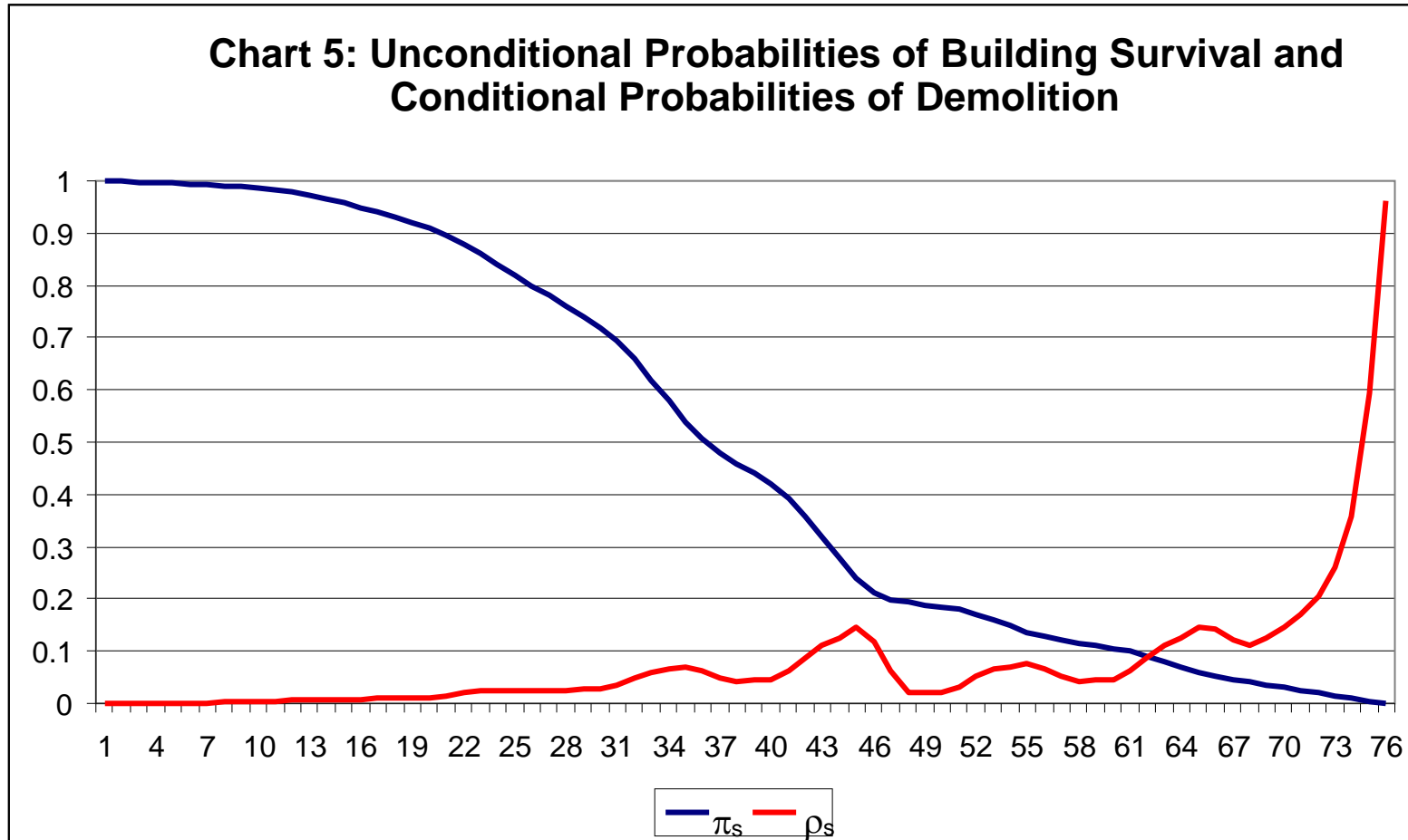
- The straight line model of depreciation is not very flexible.
- Diewert and Shimizu (2015), we implement a piece-wise linear depreciation model. The piece-wise linear aging function,  $g_A(A_{tn})$ : ***Piecewise linear function***  
**Depreciation Model.**
- $g_A(A_{tn}) \equiv D_{A,tn1}(1-\delta_1 A_{tn}) + D_{A,tn2}(1-10\delta_1-\delta_2(A_{tn}-10))$
- $+ D_{A,tn3}(1-10\delta_1-10\delta_2-\delta_3(A_{tn}-20))$
- $+ D_{A,tn4}(1-10\delta_1-10\delta_2-10\delta_3-\delta_4(A_{tn}-30))$
- $+ D_{A,tn5}(1-10\delta_1-10\delta_2-10\delta_3-10\delta_4-\delta_5(A_{tn}-40)).$
- ***Geometric Depreciation Model***
- $g_A(A_{tn}) \equiv D_{A,tn1}(1-\delta_1)^{A(t,n)} + D_{A,tn2}(1-\delta_1)^{10}(1-\delta_2)^{(A(t,n)-10)}$
- $+ D_{A,tn3}(1-\delta_1)^{10}(1-\delta_2)^{10}(1-\delta_3)^{(A(t,n)-20)}$
- $+ D_{A,tn4}(1-\delta_1)^{10}(1-\delta_2)^{10}(1-\delta_3)^{10}(1-\delta_4)^{(A(t,n)-30)}$
- $+ D_{A,tn5}(1-\delta_1)^{10}(1-\delta_2)^{10}(1-\delta_3)^{10}(1-\delta_4)^{10}(1-\delta_5)^{(A(t,n)-40)} .$
- $V_{tn} = \alpha_t(\sum_{j=1}^4 \omega_j D_{W,tnj})(\sum_{m=1}^5 \chi_m D_{EL,tnm})(1+\mu(H_{tn}))f_L(L_{tn})$   
 $+ p_{St}(1-\delta)^{A(t,n)}S_{tn} + \varepsilon_{tn} ;$

# The Various Depreciation Models Compared: Diewert and Shimizu(2018).

The top line is the straight line aging function. The green line is the multiple geometric rate function, the red line is the piece-wise linear depreciation aging function and the bottom black line is the single geometric rate aging function. The red and green lines are very close.



# Survival Biases in Property Stock: Diewert and Shimizu(2016).





## 9. Valuing the Services of OOH: User Cost versus Rental Equivalence.

- Utilities such as electricity, water and natural gas may be included in the rent for a dwelling unit that is similar to an owned unit. **The net benefit of renting an owned unit should exclude these costs** since these expenditures are covered in other categories of a Consumer Price Index.
- When calculating the benefit to the owner of a dwelling unit of renting the unit, there is a problem of determining **what is the correct market rental opportunity cost**. It turns out that all rents paid in say period t for comparable units to an owned unit can be classified into 3 categories: (i) **the rental agreement is not being renegotiated during this period**; (ii) **the rental agreement is renegotiated during this period with the same tenants** and (iii) **the rental agreement is a new one with new tenants**. Typically, there are no escalations of rents for continuing tenants during the leasehold period and often, renegotiated rents with continuing tenants are also sticky; i.e., there is not much change in these renegotiated rents. **For purposes of measuring the net benefit to an owner of renting an owned unit, category (iii) rents should be used as the appropriate comparable market rent.**

- Property taxes will be included in market rents and they should also be included in an owner's user cost. However, **if property tax payments are treated as a separate category in the CPI, then property taxes should be deducted from the comparable market rents to avoid double counting of these tax expenditures.**
- Normal maintenance expenditures on the structure will be part of market rents. **These expenditures should be deducted from the comparable market rents since these expenditures by home owners should already be included in other expenditure categories in the CPI.** Again, it is necessary to avoid double counting these expenditures. Landlords may also have considerable overhead expenses that are associated with the management of rental properties. These expenses can perhaps be grouped together with maintenance expenditures.

- The structure depreciation rate for rented dwelling units will probably be higher than the rate for comparable owned dwelling units, since owners are likely to take better care of their property and will avoid property damage. This expected difference in the value of depreciation should be deducted from the market rent that is applied to a comparable owned home.
- The owners of rental properties need to charge a small premium to the rents that they receive from rented units in order to cover the loss of rental income due to vacancies. This vacancy premium does not apply to the user cost of an owned unit and thus the comparable market rent for an owned unit should be adjusted downward to account for this vacancy factor.
- Insurance payments are included in market rents. However, in the CPI, insurance payments are included in another category so the imputed insurance premiums should be deducted from the market rent that is applied to a comparable owned home.

## Adjustment of User Cost Approach for OOH.

- 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.”*

# Use Cost Approach.

## The User Cost Approach

## The Equivalent Rent Approach

$$\begin{aligned}
 V_v^t &= \frac{y_v^t}{1+r^t} + \frac{y_{v+1}^{t+1}}{(1+r^t)(1+r^{t+1})} + \dots + \frac{y_{m-1}^{t+m-v-1}}{\prod_{i=t}^{t+m-v-1} (1+r^i)} \\
 &\quad - \frac{O_v^t}{1+r^t} - \frac{O_{v+1}^{t+1}}{(1+r^t)(1+r^{t+1})} - \dots - \frac{O_{m-1}^{t+m-v-1}}{\prod_{i=t}^{t+m-v-1} (1+r^i)}
 \end{aligned}$$

- $V_v^t$ : the initial asset value for the period  $t$ .
- $y_v^t$ : the income corresponding to  $V_v^t$ .
- $O_v^t$ : the operating income to be paid at the end of the period  $t$ .
- $r^t$ : the expected nominal discount (interest) rate for period  $t$ .

# Payment Approach and User Cost Approach.

**Basic User Cost:** **Asset Value**

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

**Interest Rate**   **Expense**   **Asset Value Increase**

- **Estimation Method:**
- The estimation method is complicated.
- **Negative problem:**
- The value becoming negative during periods of dramatic price increases.
- **Volatility problem:**
- Housing price volatility becoming greater than what it is perceived by market players.
- → **The Verbrugge Variant (VV) of the User Cost Approach.**

# Financial User Cost.

**Generalized Case:** Type B. Homeowner do not fully own their homes, but have positive home equity:

$$u^t \Big|_{typeB} \equiv r_D^t \boxed{D^t} + r^t (V^t - \boxed{D^t}) + O^t - \underbrace{(V^{t+1} - V^t)}_{\text{Expected Capital Gain}}.$$

**Asset Value**
**Expense**

**Interest**
**Interest**
**Debt**
**Expected Capital Gain**

**Rate for**
**Rate for**

**Mortgage**
**Investment**

Type A. Homeowner owns their home (full equity):

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

Type C. Homeowner have zero home equity:

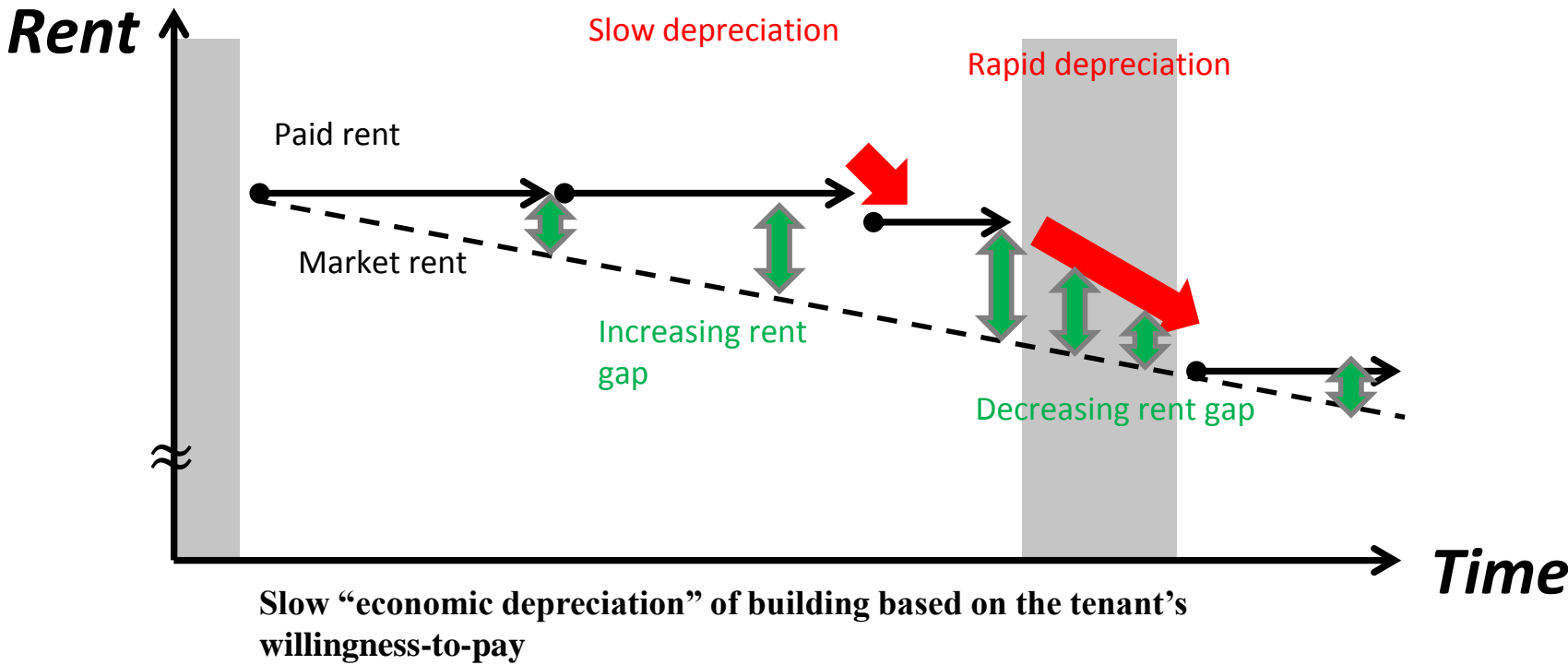
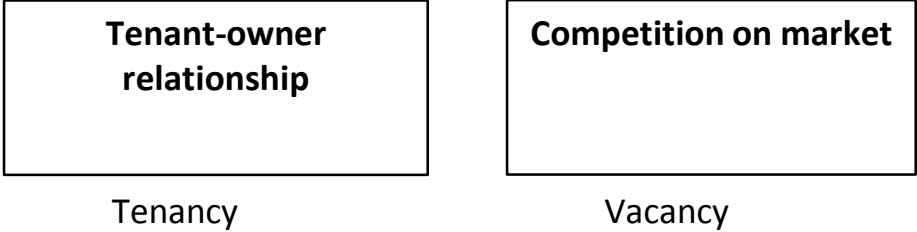
$$u^t \Big|_{typeC} \equiv r_D^t \boxed{D^r} + O^t - (\overline{V^{t+1}} - V^t).$$

## 10. Stickiness in Housing Rent.

- There are differences between “contract rent (paying rent)” and “market rent(new contract rent)”.
- “Contract rent” refers to the rent paid by a renter who has a long term rental contract with the owner of the dwelling unit and “market rent” is the rent paid by the renter in the first period after a rental contract has been negotiated.
- If we value the services of an owner occupied dwelling at its current opportunity cost on the rental market, we should be using **market rent rather than contract rent.**



# Lifecycle over tenancy and vacancy



Suzuki, Asami and Shimizu(2018)

# Housing Rent Change

Price Change

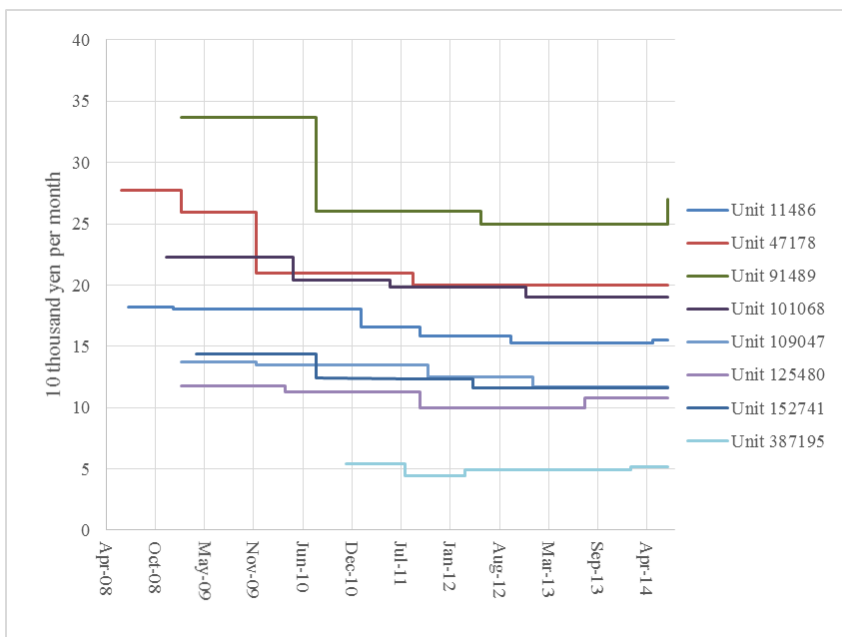
$$\Delta R_{it} \equiv R_{it} - R_{it-1}$$

Probability of event on *New Contract* ( $I^N$ ) and *Renewed Contract* ( $I^R$ )

$$\Pr(\Delta R_{it} = 0) = [1 - \Pr(I_{it}^N = 1) - \Pr(I_{it}^R = 1)]$$

$$+ \Pr(\Delta R_{it} = 0 | I_{it}^N = 1) \Pr(I_{it}^N = 1)$$

$$+ \Pr(\Delta R_{it} = 0 | I_{it}^R = 1) \Pr(I_{it}^R = 1)$$



## Rent stickiness.

Yearly rigidity	Country	Year (Frequency)	Literature
29%	US	1974–1981 (1 year)	Genesove (2003)
32%	Turkey	2008–2011 (1 year)	Aysoy et al. (2014)
49%	US	1998–2008 (half year)	Verbrugge & Gallin (2017)
78%	Germany	1998–2003 (1 year)	Hoffmann & Kurz-Kim (2006)
89%	Tokyo, Japan	<b>March 2008 (1 month)</b> 1986–2006 (bet. new contract)	Shimizu et al. (2010)

- Adjust more upon [tenant change](#)
- Public survey data: *cross-sectional* (i.e., snapshot) observation
  - Shimizu et al. (2010) capture the changes in housing rents from the previous month, and distinguish whether the rent is being charged at contract renewal, at tenant turnover, or during the term of a contract
- Small sample size: univariate analysis

Suzuki, Asami and Shimizu(2018)

## 11. Conclusions.

- The fundamental problem of accounting arises when constructing a price index for the services of a durable good: **imputations will have to be made in order to decompose the initial purchase cost into period by period components over the life time of the durable good.** The method of imputation will involve assumptions which may not be accepted by all interested parties. In spite of this difficulty, it will be useful for **statistical agencies to construct analytical series for the services of long lived consumer durables that can be made available to the public.** This will meet the needs of different users.
- The valuation of **the services of housing is very difficult due to the fact that housing services are unique:** the location of each dwelling unit is unique and the location affects the land price component of the property and thus affects rents and user costs. Moreover, the structure component of housing does not remain constant over time due to depreciation of the structure and to renovation expenditures.

## Specific recommendations.

- There are three main approaches for the treatment of consumer durables in a CPI: the acquisitions approach, the rental equivalence approach and the user cost approach.
- The acquisitions approach is **suitable (for most purposes) for durable goods with a relatively *short expected useful life*.**
- The acquisitions approach is particularly useful for **central bankers who want consumer inflation indexes that are largely free from imputations.**
- The acquisitions approach provides an index for purchases of a durable good and this index is a required input into the construction of a user cost index.

## Specific recommendations. (cont)

- The remaining two approaches are **useful for measuring the flow of services yielded by consumer durables over their useful lives.**
- At present, only the flow of services for OOH is estimated by national statistical agencies (using the rental equivalence or user cost approaches) because this information is required for the **international System of National Accounts.**
- The acquisitions approach will substantially understate the value of the service flow from consumer durables that have relatively long lives. Hence **at least one of the rental equivalence or user cost approaches should be implemented by statistical agencies for durables with long lives.**
- Examples of long lived durables are automobiles and household furnishings.

## Specific recommendations. (cont)

- The rental equivalence approach to the valuation of the services provided by consumer durables is **the preferred method of valuation when rental or leasing markets for the class of durables exist**, because, in principle, no imputations are required to implement this method.
- However, when **rental markets for the durable good under consideration are thin or do not exist**, then the user cost approach should be used to value the services of the durable good.
- The user cost approach requires the construction of a price index for new acquisitions of the durable. It also requires **a model of depreciation and assumptions about the opportunity cost of capital and about expected asset inflation rates**. Thus the user cost approach necessarily involves imputations.

## Specific recommendations. (cont)

- In order to avoid unnecessary volatility in the user costs, **long run expected asset inflation rates should be used in the user cost formula.**
- Rental markets for high end dwelling units are generally nonexistent or very thin and hence, it may not be possible to use the rental equivalence approach for high end OOH. Even if some rental information on high end housing units is available, usually these rents are far below the corresponding user costs.
- However, for housing, **the “comparable” rental property may not be exactly the same as the owned unit.** Moreover, the observed rents may include insurance services and the services of some utilities and possibly furniture. It will be difficult to extract these costs from the observed rent.



## Specific recommendations. (cont)

- The “true” opportunity cost for using the services of a consumer durable is **the maximum of its rental price (if it exists) and its user cost**. Thus the use of the rental equivalence approach to value the services of a high end housing unit will understate the “true” service flow by a substantial amount.
- In order to construct national balance sheets and to measure national multifactor productivity, **it is necessary to decompose the selling prices of dwelling units into structure and land components**. This can be done for both detached housing and condominium units using hedonic regression techniques, ***Builder’s Model***. This decomposition is also required in order to construct accurate user costs for housing units since depreciation applies to the structure but not to the land component of the property.
- When constructing price indexes for rental housing, statistical agencies need to make an adjustment to observed rents for the same unit for **depreciation of the structure and possible improvements to the structure**.

## Specific recommendations. (cont)

- Long run user costs and rents will tend to be approximately equal to each other for lower end housing units since this type of housing unit will be built by property developers who provide rental housing and they need to set rents that are approximately equal to their long run user costs. However, short run dynamics can cause user costs and rents to diverge even for lower end housing units.
- When using observed rents to measure the service flow for comparable owned properties, statistical agencies should use **new contract rents** to evaluate the service flow for the owned units since rents for continuing tenants may be sticky and not reflect current opportunity costs.

## Specific recommendations. (cont)

- When constructing user costs for OOH, **statistical agencies need to avoid double counting of some housing related costs that may appear elsewhere in the CPI such as insurance costs.** Similar double counting problems may arise with housing rents, which may include the services of some utilities or furniture and of course, the housing rent will include insurance costs. In principle, these associated costs should be deducted from the observed rent and placed in the appropriate classification of the CPI. In practice, this is a difficult imputation problem.
- A variant of the acquisitions approach is sometimes applied to OOH. This variant excludes the land component of the purchase of a new house. **Thus this variant reduces to a construction cost index for housing with some allowance made for builders' profit margins.** This variant generates valuations for OOH that are far below the comparable rental equivalent and user cost valuations. It is difficult to justify the use of this variant in a CPI.

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