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Alternative approaches to CPPIs for Tokyo

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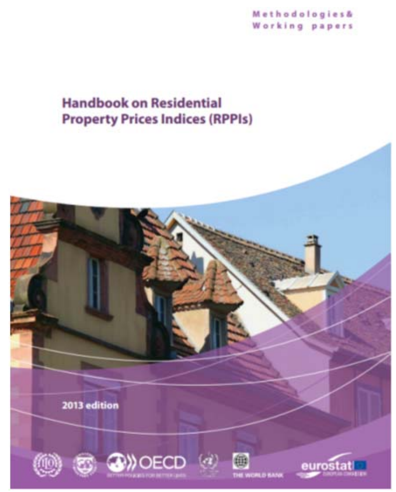
Why Property Price Indicators?

- The European statistical agency, Eurostat, is about to publish a Residential Property Price Index (RPPI) Handbook with UN,OECD, IMF, BIS and World Bank.

- This book describes some of the problems associated with constructing price indexes for residential house prices and gives advice on methods that could be used in order to construct house price indexes.

- The Global Financial Crisis has several causes but a main cause was a property bubbles in the U.S, Japan, Sweden.



Why have national statistical agencies not constructed best practice regional property price indexes?

- It is very difficult to construct accurate property price indexes and so statistical agencies have been reluctant to allocate their scarce resources to the construction of indexes where there has not been international agreement on how exactly to construct such an index;

- Property prices by themselves do not occupy an important position in the major statistics that countries construct; i.e., property price indexes do not appear directly in either the Consumer Price Index or in the main components of GDP.

Property Price Indexes and Official Statistics

Consumer Price Index or CPI

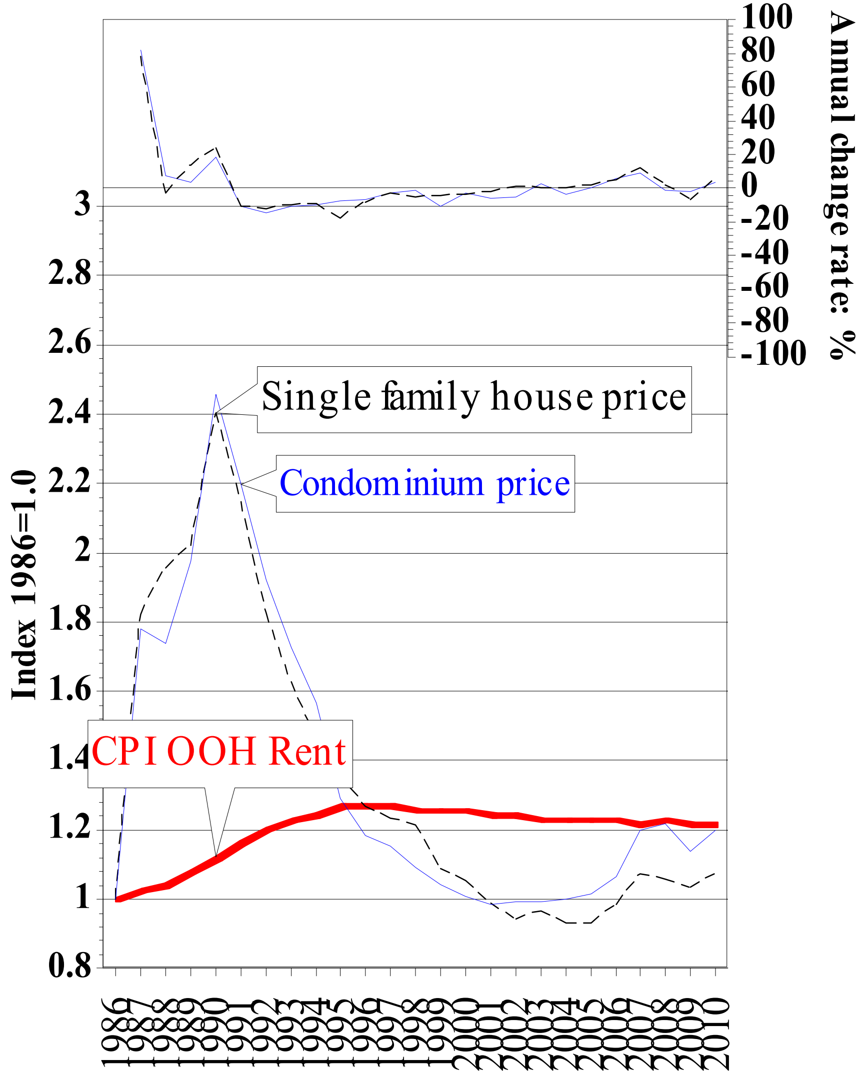
- Current CPI practise either ignores owner occupied housing or prices it according to what the rental value of the house is.
- →Property price indexes also play an important role in the balance sheet accounts of a country.

National Account or SNA

- When nominal balance sheet items are deflated, it is necessary to have accurate indexes for the structure part of a house and for the land component.
- →Thus for balance sheet purposes, it is important to be able to decompose an *overall house price index* into consistent ***land*** and ***structure*** subcomponents.

Case of Japan.

The Consumer Price Index for owner occupied housing rent, did not exhibit a large swing even during the bubble period. **Shimizu, Nishimura and Watanabe (2010)**



The most important link between asset prices and goods & services prices is the one through housing rents (**Diewert and Nakamura 2011, Goodhart 2001**)

1. Housing rents account for **more than one fourth of personal spending.**
2. Imputed Rent for OOH also represents a weight of approximately 10% in the SNA

2009= 10.1%, 2010 =9.85%

International Handbook on COMMERCIAL PROPERTY PRICE INDICATORS

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- **7. Additional indicators for commercial property**
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1. Introduction: Alternative approaches to CPPIs for Tokyo

- Our goal is to obtain not only an overall commercial property price index but to have a **decomposition of the overall index into structure and land components.**
- **Contents:**
- Section 2: Data set.
- Section 3: The Asset Value Price
- **Section 4: A National Balance Sheet Accounting**
- Section 5: Traditional Hedonic Regression
- Section 6: The Builder's Model
- Section 7: The Builder's Model with Geometric Depreciation Rates
- Section 8: Conclusion.

2. The Tokyo REIT Data

- This paper uses published information on the **Japanese Real Estate Investment Trust (REIT)** market in the Tokyo area.
- **Balanced panel of observations on 50 REITs for 22 quarters**, starting in Q1 of 2007 and ending in Q2 of 2012.

- **V :** the assessed value of the property(yen)
- **CE:** the quarterly capital expenditures made on the property(yen)
- **L:** the area of the land plot in square meters (m2)
- **S:** the total floor area of the structure in m2
- **A:** the age of the structure in quarters

Table 1: Descriptive Statistics for the Variables

Name	No. of Obs.	Mean	Std. Dev	Minimum	Maximum
V	1,100	4984.8	3417.8	984.3	18600
S	1,100	5924.8	3568.1	2099	18552
L	1,100	1106.3	718.2	294.5	3355
A	1,100	83.9	25.2	16.7	156.7
CE	1,100	6.08	11.94	0.06	85.49

There were fairly high correlations between the V, S and L variables. The correlations of the selling price V with structure and lot area S and L were 0.725 and 0.532 respectively and the correlation between S and L was 0.840.

3. The Asset Value Price Index for Commercial Properties in Tokyo

- Denote the estimated asset value for REIT n during quarter t by V_{tn} for t = 1,...,22 and n = 1,...,50 where t=1 corresponds to the first quarter of 2007 and t = 22 corresponds to the second quarter of 2012.
- *If we ignore capital expenditures and depreciation of the structures on the properties, each property can be regarded as having a constant quality over the sample period.*

- Thus each property value at time t for REIT n, V_{tn}, can be decomposed into a **price component, P_{tn}**, times **a quantity component, Q_{tn}**, which can be regarded as being constant over time.

Lowe (1823) index:

- We can choose units of measurement so that each quantity is set equal to unity.
- Thus the price and quantity data for the 50 REITs has the following structure: $Q_{tn} \equiv 1$; $P_{tn} = V_{tn}$ for $t = 1,\ldots,22$ and $n = 1,\ldots,50$.
- The *asset value price index* for period t for this group of REITs is the following **Lowe (1823) index**:

- **(1)** $\mathbf{P_A^t \equiv \sum_{n=1}^{50} P_{tn} Q_{1n} / \sum_{n=1}^{50} P_{1n} Q_{1n} = \sum_{n=1}^{50} V_{tn} / \sum_{n=1}^{50} V_{1n}}$;
- $t = 1,\ldots,22.$

Three major problems with the assessed value price index:

- a) The index relies on assessed values for the properties and there is some evidence that **assessed values are smoother and lag behind indexes** that are based strictly on sales at market values;(Shimizu and Nishimura (2006))

- b) The index **does not take into account that *capital expenditures*** will generally change the quality of each property over time (so that the Q_{tn} are not in fact constant) and

- c) The index **does not take into account *depreciation*** of the underlying structure, which of course also changes the quality of each property.

4. A National Balance Sheet Accounting Approach to the Construction of Commercial Property Price Indexes.

- National income accountants build up capital stock estimates for a production sector ***by deflating investments*** by asset and then ***adding up depreciated*** real investments made in prior periods.
- For commercial ***property capital expenditures*** and the expenditures on the initial structure, we will more or less follow national income capital stock construction procedures.
- We will assume that the assessed values for each property represents a good estimate for the total value of the structure and the land that the structure sits on.

Sum of three components= V_{tn}

- We postulate that the assessed asset value of REIT n in quarter t, V_{tn}, is equal to the sum of three components:

- The ***value of the land plot*** V_{Ltn} for the property;
- The ***value of the structure*** on the property, V_{Stn}, and
- The ***value of the cumulated (but also depreciated) capital expenditures*** on the property made in prior periods, V_{CEtn}.

- **(2)** $\mathbf{V_{tn} = V_{Ltn} + V_{Stn} + V_{CEtn}}$;
  $n = 1,\ldots,50$; $t = 1,\ldots,22$.

The ***value of the land plot*** V_{Ltn}

- We start off by considering the decomposition of the property land values, V_{Ltn}, into price and quantity components; i.e., we assume that the following equations hold:

- **(3)** $\mathbf{V_{Ltn} = P_{Ltn}Q_{Ltn}}$; $\mathbf{Q_{Ltn} = L_{tn} = L_n}$;
  $n = 1,...,50$; $t = 1,...,22$

- where L_n (which is equal to L_{tn}) is the area of the land plot for REIT n, which is part of our data base (and constant from period to period), and P_{Ltn} is the price of a square meter of land for REIT n in quarter t (which is not known yet).

The *value of the structure* on the property, V_{Stn}

- **(4)** $V_{Stn} = .3P_{St}S_{tn}(1-\delta_S)^{A(t,n)}$;
  $n = 1,\ldots,50$; $t = 1,\ldots,22$
- where $A(t,n) \equiv A_{tn}$. Thus we obtain the following decomposition of V_{Stn} into price and quantity components:

- **(5)** $V_{Stn} = P_{Stn}Q_{Stn}$; $P_{Stn} \equiv P_{St}$; $Q_{Stn} \equiv .3S_{tn}(1-\delta_S)^{A(t,n)}$;
  $n = 1,\ldots,50$; $t = 1,\ldots,22$
- where P_{St} is the known official construction price index for quarter t (lagged one quarter), S_{tn} is the known floor space for REIT n in quarter t, A(t,n) is the known age of REIT n in quarter t and $\delta_S = 0.005$ is the assumed known quarterly geometric structure depreciation rate.

The ***value of the cumulated (but also depreciated) capital expenditures*** on the property

- Define the capital expenditures of REIT n in quarter t as CE_{tn}.
- We need a deflator to convert these nominal expenditures into real expenditures. It is difficult to know precisely what the appropriate deflator should be. We will simply assume that the official structure price index, P_{St}, is a suitable deflator. Thus define *real capital expenditures* for REIT n in quarter t, q_{CEtn}, as follows:

- **(6)** $\mathbf{q_{CEtn} \equiv CE_{tn}/P_{St}}$; n = 1,...,50 ; t = 1,...,22.

Depreciation rate for capital expenditures

- We assume that the **quarterly geometric depreciation rate for capital expenditures is δ_{CE} = 0.10 or 10% per quarter.**
- The next problem is the problem of determining the starting stock of capital expenditures for each REIT, given that we do not know what capital expenditures were before the sample period. We provide a solution to this problem in two stages. First, we generate *sample average real capital expenditures* for each REIT n, q_{CEn}, as follows:

- **(7)** $q_{CEn} \equiv \sum_{t=1}^{22} q_{CEtn}/22$; n = 1,...,50.

Starting stock of capital expenditures

- Our next assumption is that each REIT n has a starting stock of capital expenditures equal to depreciated investments for 20 quarters (or 5 years) equal to the REIT n sample average investment, q_{CEn}, defined above by (7). Thus the *starting stock of CE capital* for REIT n is Q_{CE1n} defined as follows:

- **(8)** $\mathbf{Q_{CE1n} \equiv q_{CEn}[1 - (1-\delta_{CE})^{21}]/\delta_{CE}}$; n= 1,...,50.

The REIT capital stocks for capital expenditures

- The REIT capital stocks for capital expenditures can be generated for quarters subsequent to quarter 1 using the usual geometric model of depreciation recommended by Hulten and Wykoff (1981), Jorgenson (1989) and Schreyer (2001) (2009) as follows:

- **(9)** $\mathbf{Q_{CEtn} \equiv (1-\delta_{CE})Q_{CE,t-1,n} + q_{CE,t-1,n}}$;
  $t = 2,3,...,22$; $n = 1,...,50$.

- Note that Q_{CEtn} is now completely determined for $t = 1,...,22$ and $n = 1,...,50$ and the corresponding price P_{St} is also determined.

Value for the stock of capital expenditures

- Thus an estimated value for the stock of capital expenditures of REIT n for the beginning of period t, V_{CEtn}, can be determined by multiplying P_{St} by Q_{CEtn}; i.e., we have:
- **(10)** $\mathbf{V_{CEtn} \equiv P_{CEtn}Q_{CEtn}; P_{CEtn} \equiv P_{St}}$;
  $t = 1,...,22$; $n = 1,...,50$
- where the Q_{CEtn} are defined by (8) and (9).
- Now that the asset values V_{tn}, V_{Stn} and V_{CEtn} have all been determined, the price of land for REIT n in quarter t, P_{Ltn}, can be determined residually using equations (2) and (3):
- **(11)** $\mathbf{P_{Ltn} \equiv [V_{tn} - V_{Stn} - V_{CEtn}]/L_n}$;
  $n = 1,...,50$; $t = 1,...,22$.

Definition of 3 components for Commercial Property

- The above material shows how to construct estimates for the price of land, structures and capital expenditures for each REIT n for each quarter t (**P_{Ltn}, P_{Stn} and P_{CEtn}**) and the corresponding quantities (**Q_{Ltn}, Q_{Stn} and Q_{CEtn}**).
- Now use this price and quantity information in order to construct *quarterly value aggregates* (over all 50 REITs in our sample) for the properties and for the land, structure and capital expenditure components; i.e., make the following definitions:

- **(12)** $V^t \equiv \sum_{n=1}^{50} V_{tn}$; $V_L{}^t \equiv \sum_{n=1}^{50} V_{Ltn}$; $V_S{}^t \equiv \sum_{n=1}^{50} V_{Stn}$; $V_{CE}{}^t \equiv \sum_{n=1}^{50} V_{CEtn}$; $t = 1,\ldots,22$.

Laspeyres land price indexes

- Define the *Laspeyres chain link land index* going from quarter t−1 to quarter t, $P_{L,Land}^{t-1,t}$, as follows:
- **(13)** $\mathbf{P_{L,Land}^{t-1.t} \equiv \sum_{n=1}^{50} P_{Ltn}Q_{L,t-1,n}/\sum_{n=1}^{50} P_{L,t-1,n}Q_{L,t-1,n}}$; t = 2,3,...,22.
- The above chain links are used in order to define the *overall Laspeyres land price indexes*, $P_{L,Land}^{t}$, as follows:
- **(14)** $\mathbf{P_{L,Land}^{1} \equiv 1 \; ; \; P_{L,Land}^{t} \equiv P_{L,Land}^{t-1} \, P_{L,Land}^{t-1,t}}$ **;** **t = 2,3,...,22.**
- Thus the Laspeyres price index starts out at 1 in period 1 and then we form the index for the next period by updating the index for the previous period by the chain link indexes defined by (13).

Paasche chain link land index

- Define the *Paasche chain link land index* going from quarter t−1 to quarter t, $P_{P,Land}^{t-1,t}$, as follows:
- **(15)** $P_{P,Land}^{t-1.t} \equiv \sum_{n=1}^{50} P_{Ltn}Q_{Ltn}/\sum_{n=1}^{50} P_{L,t-1,n}Q_{Ltn}$; $t = 2,3,...,22$

- The above chain links are used in order to define the overall Paasche land price indexes, $P_{P,Land}^{t}$, as follows:
- **(16)** $P_{P,Land}^{1} \equiv 1$; $P_{P,Land}^{t} \equiv P_{P,Land}^{t-1} P_{P,Land}^{t-1,t}$; $t = 2,3,...,22.$

Fisher ideal land price index

- The sequences of Laspeyres and Paasche land price indexes, $P_{L,Land}^t$ and $P_{P,Land}^t$, have been constructed, the *Fisher ideal land price index* for quarter t, $P_{F,Land}^t$, is defined as the geometric mean of the corresponding Laspeyres and Paasche indexes; i.e., define
- **(17) $P_{F,Land}^t \equiv [P_{L,Land}^t \, P_{P,Land}^t]^{1/2}$; $t = 1,...,22$.**
- The Fisher chained price indexes for structures and capital expenditures, $P_{F,S}^t$ and $P_{F,CE}^t$, are constructed in an entirely analogous way, except that the REIT micro price and quantity data on land, P_{Ltn} and Q_{Ltn}, are replaced by the corresponding REIT micro price and quantity data on structures, P_{Stn} and Q_{Stn}, or on capital expenditures, P_{CEtn} and Q_{CEtn}, in equations (13)-(17).

Overall chained Fisher property price index

- The price series P^t, $P_L{}^t$, $P_S{}^t$ and $P_{CE}{}^t$ can be used to deflate the corresponding aggregate value series defined above by (12), V^t,$V_L{}^t$, $V_S{}^t$ and $V_{CE}{}^t$, in order to form *implicit quantity or volume indexes*; i.e., define the following aggregate quantity indexes:
- **(18) $Q^t \equiv V^t/P^t$; $Q_L{}^t \equiv V_L{}^t/P_L{}^t$; $Q_S{}^t \equiv V_S{}^t/P_S{}^t$; $Q_{CE}{}^t \equiv V_{CE}{}^t/P_{CE}{}^t$; $t = 1,...,22$.**
- Q^t can be interpreted as an estimate of the real stock of assets across all 50 REITs at the beginning of quarter t, $Q_L{}^t$ is an estimate of the aggregate real land stock used by the REITs and $Q_{CE}{}^t$ is an estimate of the real stock of capital improvements made by the REITs since they were constructed. This remains constant over time since the quantity of land used by each REIT remained constant over time.

Fisher implicit quantity indexes

- The Fisher price index of capital expenditures, P_{CE}^t, defined above also turns out to equal the official index, P_{St}.
- Thus the fairly complicated construction of the Fisher implicit quantity indexes that was explained above can be replaced by the following very simple shortcut equations:
-
- **(19)** $\mathbf{Q_S^t = V_S^t/P_{St}; Q_{CE}^t = V_{CE}^t/P_{St}}$; t = 1,...,22.
-

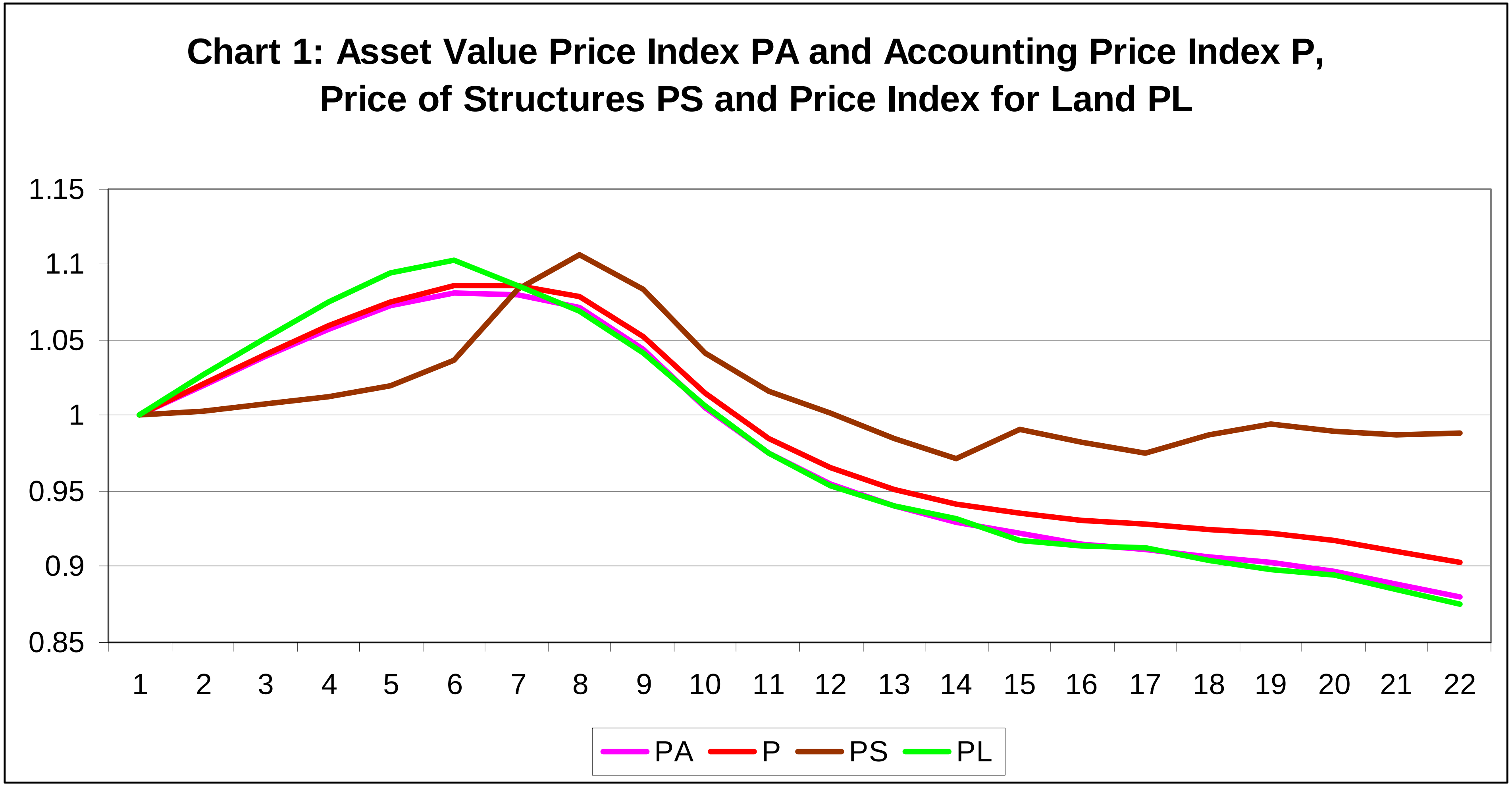


Chart 1: Asset Value Price Index PA and Accounting Price Index P, Price of Structures PS and Price Index for Land PL
1.15
1.1
1.05
1
0.95
0.9
0.85
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
PA
P
PS
PL

5. Traditional Hedonic Regression Approaches to Index Construction

- Most hedonic commercial property regression models are based on the ***time dummy approach*** where the log of the selling price of the property is regressed on either a linear function of the characteristics or on the logs of the characteristics of the property along with time dummy variables.
- The time dummy method does not generate **decompositions of the asset value into land and structure components** and so it is not suitable when such decompositions are required but the time dummy method can be used to **generate overall property price indexes**, which can then be compared with the overall price indexes P_A^t and P^t.

Time dummy hedonic regression model

- Recall that V_{tn} is the assessed value for REIT n in quarter t, $L_{tn} = L_n$ is the area of the plot, $S_{tn} = S_n$ is the floor space area of the structure and A_{tn} is the age of the structure for REIT n in period t. In the time dummy linear regression defined below by (20), we have replaced V_{tn}, L_{tn} and S_{tn} by their logarithms, $\ln V_{tn}$, $\ln L_{tn}$ and $\ln S_{tn}$. Our first time dummy hedonic regression model is defined for t = 1,...,22 and n = 1,...,50 by the following equations:

- **(20)** $\mathbf{\ln V_{tn} = \alpha + \alpha_t + \beta \ln L_{tn} + \gamma \ln S_{tn} + \delta A_{tn} + \varepsilon_{tn}}$
- where $\alpha_1,...,\alpha_{22}$, α, β, γ and δ are 25 unknown parameters to be estimated and the ε_{tn} are independently distributed normal error terms with mean 0 and constant variance.

The *overall commercial property price indexes* for Model 1

- We choose the following normalization:
- **(21) $\alpha_1 = 0$.**
- This normalization makes the overall commercial price index equal to 1 in the first period.
- The ***overall commercial property price indexes*** for Model 1, P_1^t, are defined as the exponentials of the estimated time coefficients α_t:
- **(22) $P_1^t \equiv \exp[\alpha_t]$** ;
  $t = 1,\ldots,22$.
- The resulting overall commercial property price indexes generated by Hedonic Model 1, the P_1^t.

Second time dummy hedonic regression model

- Second time dummy hedonic regression model is defined for t = 1,...,22 and n = 1,...,50 by the following equations:
-
- **(23)** $\mathbf{lnV_{tn} = \alpha + \alpha_t + \beta lnL_{tn} + \gamma lnS_{tn} + \delta A_{tn} + \omega_n + \varepsilon_{tn}}$
-
- where $\alpha_1,...,\alpha_{22}$, $\omega_1,...,\omega_{50}$, α, β, γ and δ are 76 unknown parameters to be estimated and the ε_{tn} are independently distributed normal error terms with mean 0 and constant variance.

Extended hedonic model for depreciation

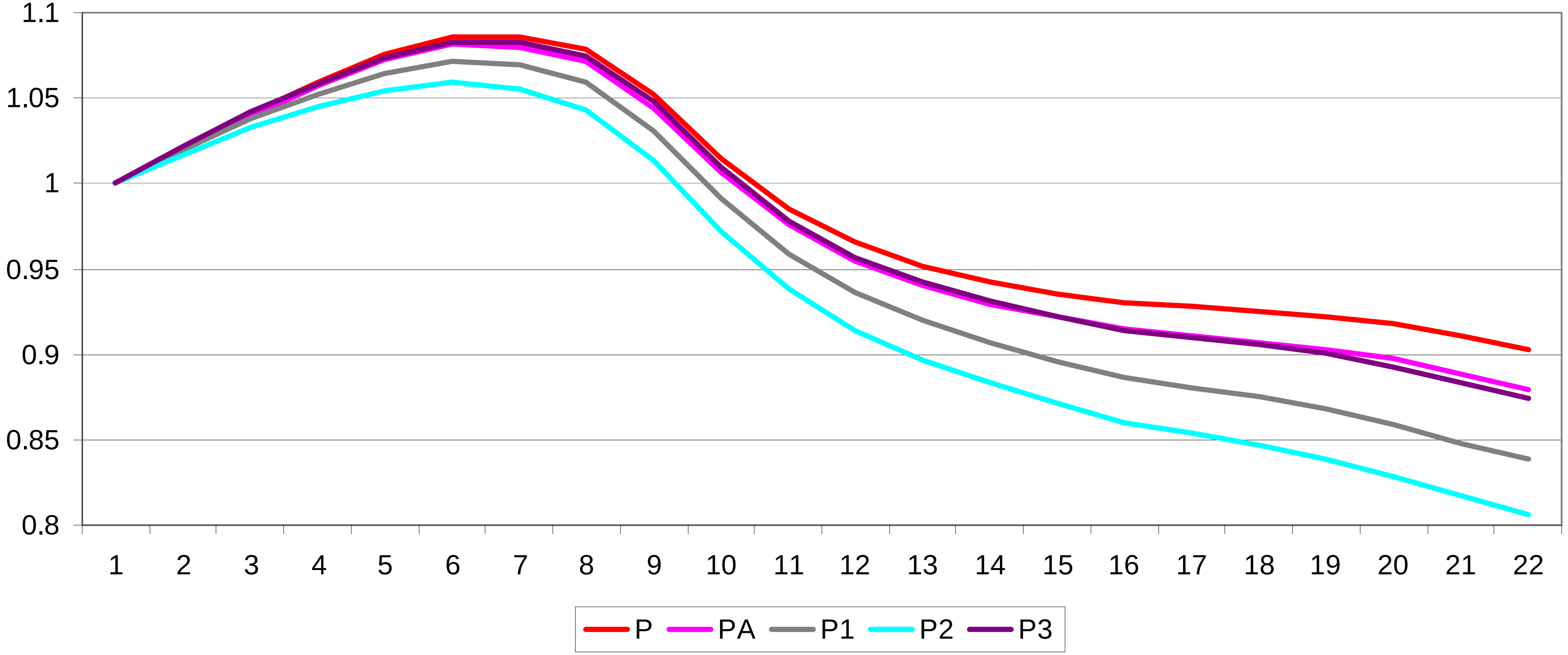
- We replace A_{tn} by the logarithm of A_{tn}, this leads to a regression model where all of the parameters are identified. Thus our *second linear regression model* is the following one which has 72 independent parameters:
- **(24)** $\mathbf{\ln V_{tn} = \alpha_t + \omega_n + \delta \ln A_{tn} + \varepsilon_{tn}}$;
  $t = 1,...,22$; $n = 1,...,50$.
- Equations (24) and (21) define Hedonic Model 2.
- The α_t parameters explain how, on average, the property values of the REIT sample shift over time and the REIT specific parameters, the ω_n, reflect the effect on REIT value of the size of the structure and the size of the land plot as well as any locational characteristics.

The *overall commercial property price indexes* for Model 2

- The *overall commercial property price indexes* for Model 2, P_2^t, were defined as the exponentials of the estimated time coefficients α_t:

- **(25) $P_2^t \equiv \exp[\alpha_t]$** ;
  t = 1,....,22.

Chart 2: Accounting Price Index P, Asset Value Price Index PA and Hedonic Price Indexes P1, P2 and P3



Two major problems with traditional log value hedonic regression

- There are two major problems with traditional log value hedonic regression models applied to property prices:
-
- These models often **do not generate reasonable estimates for structure depreciation** and
- These models essentially allow for only one factor that shifts the hedonic regression surface over time (the α_t) when in fact, there are generally two major shift factors: the price of structures and the price of land. **Unless these two price factors move in a proportional manner over time**, the usual hedonic approach will not generate accurate overall price indexes.

6. The Builder's Model Applied to Commercial Property Assessed Values

- The *builder's model* for valuing a residential property postulates that the value of a residential property is the sum of two components: **the value of the land which the structure sits on plus the value of the residential structure**.
- The total cost of the property after the structure is completed will be equal to the floor space area of the structure, say $\mathbf{S_{tn}}$ square meters, times the building cost per square meter, $\boldsymbol{\beta_t}$ say, plus the cost of the land, which will be equal to the land cost per square meter, $\boldsymbol{\gamma_{tn}}$ say, times the area of the land site, $\mathbf{L_{tn}}$.
- Thus if REIT n has a new structure on it at the start of quarter t, the value of the property, V_{tn}, should be equal to the sum of the structure and land value, $\boldsymbol{\beta_t S_{tn} + \gamma_{tn} L_{tn}}$.

Basic builder's model

- Assuming that we have information on the age of the structure n at time t, say $A_{tn} \equiv A(t,n)$ and assuming a *geometric depreciation model*, a more realistic hedonic regression model is the following *basic builder's model*:

- **(26)** $\mathbf{V_{tn} = \beta_t S_{tn} [e^{\phi}]^{A(t,n)} + \gamma_{tn} L_{tn} + \varepsilon_{tn}}$;
  $t = 1,\ldots,22;\ n = 1,\ldots,50$

- where the parameter e^{ϕ} is defined to be $1 - \delta$ and δ in turn is defined as the quarterly depreciation rate for the structure.

The Country Product Dummy methodology

- Then we will use a hedonic regression to decompose $V_{tn} - V_{CEtn}$ into structure and land components.
- We deal with the first problem by applying the Country Product Dummy methodology to the land component on the right hand side of equations (26) above; i.e., we set

- **(27)** $\boldsymbol{\gamma_{tn} = \alpha_t \omega_n}$;
  t = 1,...,22; n = 1,...,50.

Nonlinear regression

- We also set the new structure prices for each quarter t, β_t, equal to a single price of structure in quarter 1, say β, times our official construction cost index $P_S{}^t$ described in earlier sections. Thus we have:
- **(28) $\beta_t = \beta P_S{}^t$;**
  t = 1,...,22.
- Replacing V_{tn} by $V_{tn} - V_{CEtn}$ and substituting (27) and (28) into equations leads to the following nonlinear regression model:
- **(29) $V_{tn} - V_{CEtn} = \beta P_S{}^t S_{tn}[e^{\phi}]^{A(t,n)} + \alpha_t \omega_n L_{tn} + \varepsilon_{tn}$;**
  t = 1,...,22; n = 1,...,50.

New land price series

- We need to explain how our new land price series P_{L4}^t can be combined with our structures (and capital expenditures) price series P_S^t. Denote the estimated Model 4 parameters as β^*, $\alpha_1^* \equiv 1, \alpha_2^*,...,\alpha_{22}^*$, ϕ^* and $\omega_1^*,...,\omega_{50}^*$.
- We can break up the fitted value on the right hand side of equation (29) for observation tn into *a fitted structures component*, V_{S4tn}^*, and a *fitted land component*, V_{L4tn}^*, for n = 1,...,50 and t = 1,...,22 as follows:

- **(30)** $\mathbf{V_{S4tn}^* \equiv \beta^* P_S^t S_{tn} [e^{\phi^*}]^{A(t,n)}}$;
- **(31)** $\mathbf{V_{L4tn}^* \equiv \alpha_t^* \omega_n^* L_{tn}}$.

Structure Value and Land Value

- Now form structures and capital expenditures aggregate (over all REITS), V_{S4t}^{*}, by adding up the fitted structure values V_{S4tn}^{*} defined by (30) and the capital expenditures capital stocks V_{CEtn} that were defined by equations (10) in section 4 for each quarter:
- **(32)** $\mathbf{V_{S4t}^{*} \equiv \sum_{n=1}^{50} [V_{S4tn}^{*} + V_{CEtn}]}$; $t = 1,...,22.$

- In a similar fashion, form a land value aggregate (over all REITS), V_{L4t}^{*}, by adding up the fitted land values V_{L4tn}^{*} defined by (31) for each quarter t:
- **(33)** $\mathbf{V_{L4t}^{*} \equiv \sum_{n=1}^{50} V_{L4tn}^{*}}$; $t = 1,...,22.$

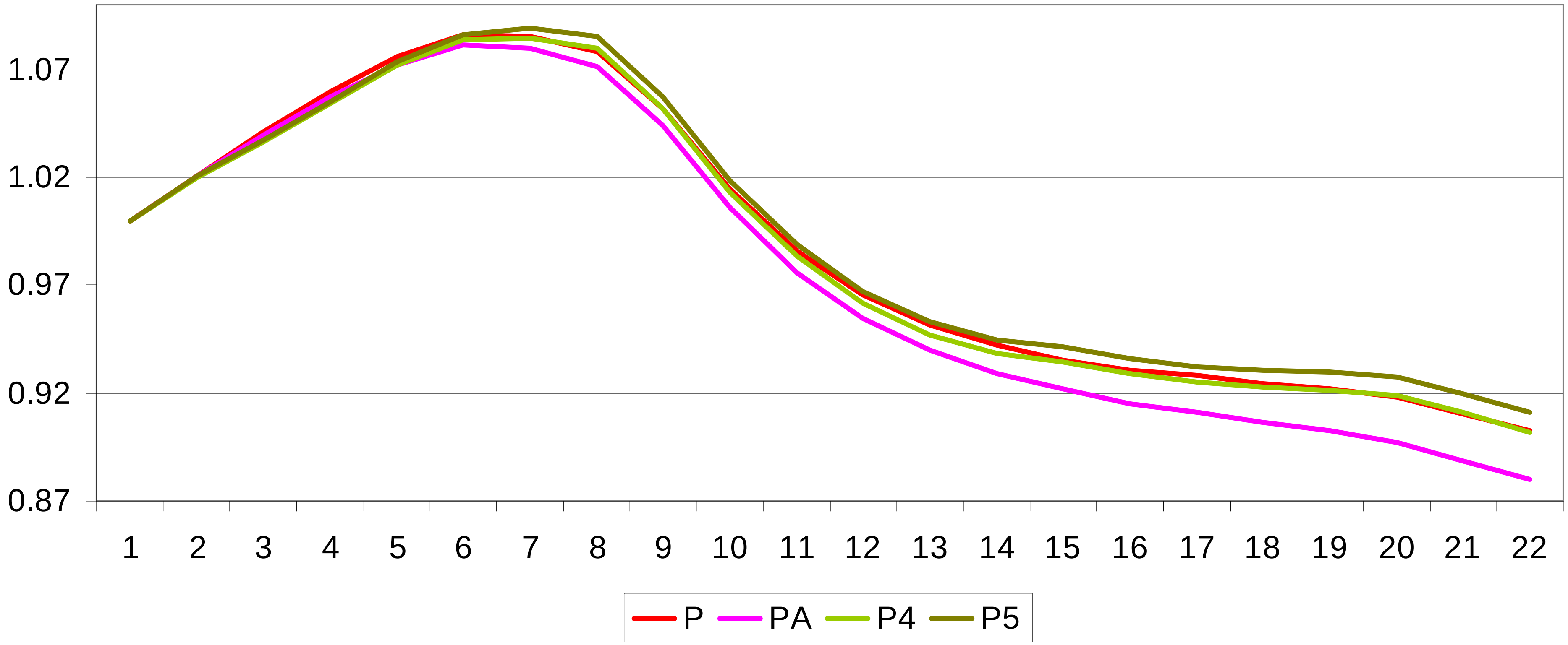
The chained Fisher price index

- Now define the *period t aggregate structure* (including capital expenditures) *quantity* or volume, Q_{S4t}^{*}, by (34) and *the period t aggregate land quantity* or volume, Q_{L4t}^{*}, by (35):

- **(34)** $\mathbf{Q_{S4t}^{*} \equiv V_{S4t}^{*}/P_{S}^{t}}$;
  t = 1,...,22;
- **(35)** $\mathbf{Q_{L4t}^{*} \equiv V_{L4t}^{*}/P_{L4}^{t}}$;
  t = 1,...,22.

- Thus for each period t, we have 2 prices, P_S^t and P_{L4}^t, and the corresponding 2 quantities, Q_{S4t}^{*} and Q_{L4t}^{*}. We form an overall commercial property price index, P_4^t, by calculating the chained Fisher price index of these two price components.

Chart 3: Accounting Method Price Index P, Asset Value Index, Builder's Model Price Indexes P4 and P5



7. The Builder's Model with Geometric Depreciation Rates that Depend on the Age of the Structure

- The age of the structures in our sample of Tokyo commercial office buildings ranges from about 4 years to 40 years. One might question **whether the quarterly geometric depreciation rate is constant from year to year**. Thus in this section, we experimented with a model that allowed for different rates of geometric depreciation every 10 years.
- However, we found that there were not enough observations of "young" buildings to accurately determine separate depreciation rates for the first and second age groups so we divided observations up into three groups where the change in the depreciation rates occurred at ages (in quarters) 80 and 120. observations where the building was 0 to 80 quarters old, 80 to 120 quarters old and over 120 quarters old.

Three *Age dummy variables*

- We label the three sets of observations that fall into the three groups as **groups 1-3**. For each observation n in period t, we define the three ***Age dummy variables***, D_{tnm}, for m = 1,2,3 as follows:

- **(36) $D_{tnm} \equiv 1$ if observation tn has a building whose age belongs to group m;**
- **$\equiv 0$ if observation tn has a building whose age is *not* in group m.**

The function of age A_{tn}

- These dummy variables are used in the definition of the following function of age A_{tn}, $g(A_{tn})$, defined as follows where the break points, A_1 and A_2, are defined as $A_1 \equiv 80$ and $A_2 \equiv 120$:
- **(37)** $g(A_{tn}) \equiv \exp\{D_{tn1}\phi_1 A_{tn} + D_{tn2}[\phi_1 A_1 + \phi_2(A_{tn} - A_1)] + D_{tn3}[\phi_1 A_1 + \phi_2(A_2 - A_1) + \phi_3(A_{tn} - A_2)]\}$
- where ϕ_1, ϕ_2 and ϕ_3 are parameters to be estimated. As in the previous section, each ϕ_i can be converted into a depreciation rate δ_i where the δ_i are defined as follows:
- **(38)** $\delta_i \equiv 1 - \exp[\phi_i]$; $i = 1,2,3$.

New nonlinear regression model

- Now we are ready to define our new nonlinear regression model that generalizes the model defined by (29) and (21) in the previous section. *Model 5* is the following nonlinear regression model:

- **(39)** $\mathbf{V_{tn} - V_{CEtn} = \beta P_S{}^t S_{tn} g(A_{tn}) + \alpha_t \omega_n L_{tn} + \varepsilon_{tn}}$;
  t = 1,...,22; n = 1,...,50

- where $g(A_{tn})$ is defined by (37).

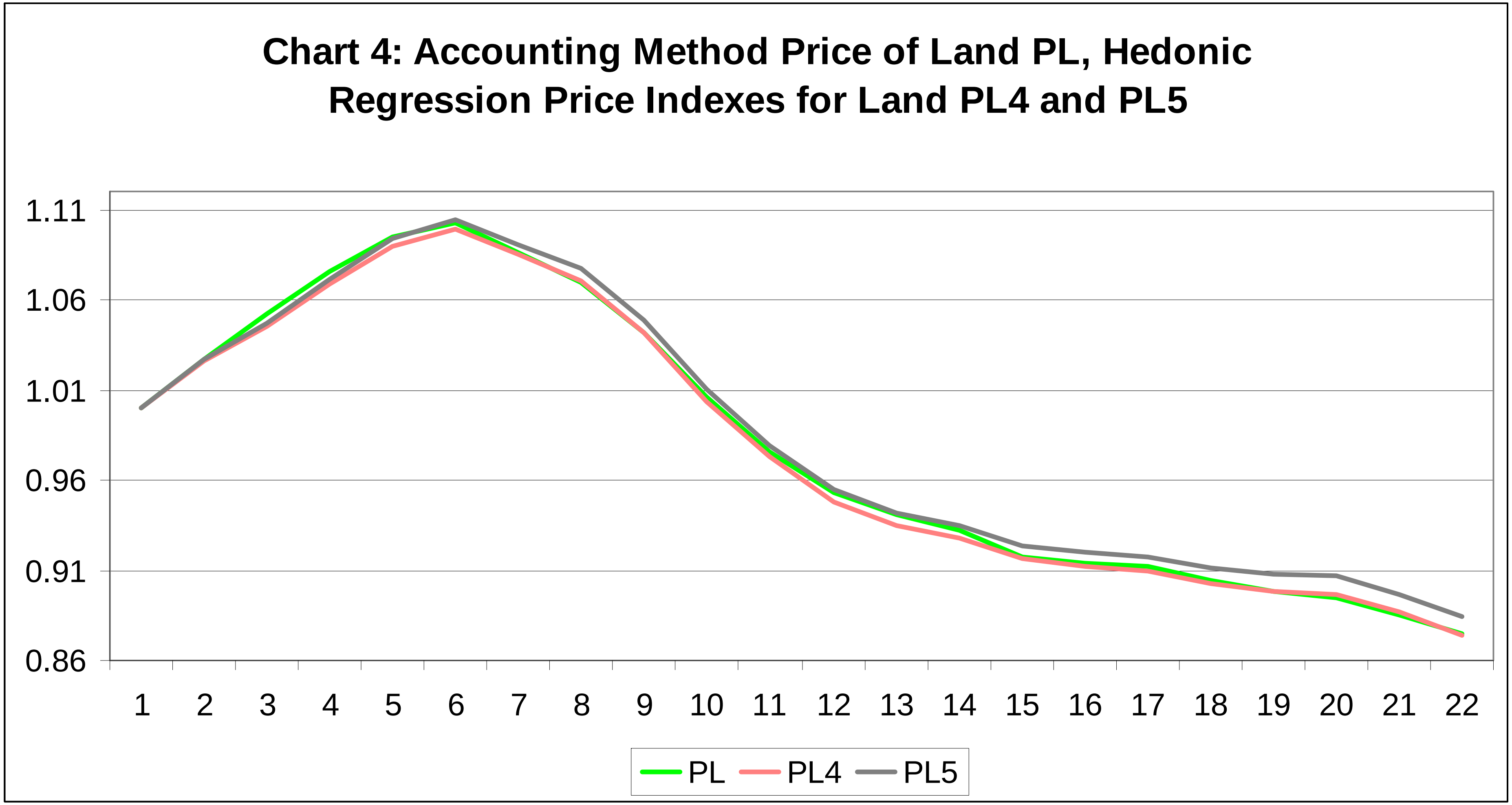


Chart 4: Accounting Method Price of Land PL, Hedonic Regression Price Indexes for Land PL4 and PL5
1.11
1.06
1.01
0.96
0.91
0.86
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
PL
PL4
PL5

8. Conclusion

- The traditional time dummy approach to hedonic property price regressions does not always work well. The basic problem is that there are two main drivers of property prices over time: changes in the price of land and changes in the price of structures. The hedonic time dummy method allows for only one shifter of the hedonic surface when in fact there are at least two major shifters. Moreover, the traditional approach does not lead to sensible decompositions of overall price change into land and structure component changes.
- The simple asset value price index suggested in section 3 seemed to work better than indexes based on the traditional time dummy hedonic regression approach.

- The accounting method for constructing land, structure and overall property price indexes that was described in section 4 turned out to generate price indexes that were pretty close to the hedonic indexes based on the builder's model that were developed in sections 6 and 7.
- The methods suggested in sections 4, 6 and 7 are practical and probably could be used by statistical agencies to improve their balance sheet estimates for commercial properties.
- We experimented with capitalizing REIT Net Operating Income into capital stock indexes but the volatility in REIT cash flows presents practical problems in implementing this method. Even after smoothing cash flows, we could not generate sensible capital stock estimates with our data set.

- We also tried to use an econometric model to determine what an appropriate quarterly depreciation rate for capital expenditures should be but we found that the likelihood function was very flat over a very large range of depreciation rates so we simply settled on a quarterly rate of 10% without good evidence to back up this rate.
- The depreciation rates that we estimate in sections 6 and 7 understate the actual amount of structure depreciation that takes place. Our approach is fine as far as it goes but it applies only to continuing structures. Unfortunately, structures are not all demolished at the same age: many structures still generate cash flow but yet they are demolished before they are fully amortized. Taking this effect into account is of course possible, but it is still an open question on how exactly should we deal with this problem.

Overall conclusion

- Our overall conclusion is that constructing usable commercial property price indexes is **a very challenging task**;
- **a much more difficult task that the construction of residential property price indexes.**

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- **International Handbook on COMMERCIAL PROPERTY PRICE INDICATORS**

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Appendix1: Data sources and quality adjustments of commercial property price indexes

Name	Price data	Estimation method	Frequency	Coverage
Urban Land Price Index	Appraisal prices	Mean	Bi-annually	Japan
IPD Property Index	Appraisal prices	Mean	Monthly	25 contries
NCRIEF Property Index	Appraisal prices	Mean	Quarterly	U.S.
MIT/CRE TBI	Transaction prices	Hedonic	Quarterly	U.S.
Moody's/RCA CPPI	Transaction prices	Repeat sales	Monthly	U.S.
FTSE NAREIT PureProperty Index	REIT returns	De-levered regression	Daily	U.S.

Appendix2: Real Estate and Financial Assets and Real Estate Investment Market in 2010.