DECOMPOSING A CPPI INTO LAND AND STRUCTURES COMPONENTS

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CPPI HANDBOOK 2ND DRAFT CHAPTER 4

PREPARATION OF AN INTERNATIONAL HANDBOOK ON COMMERCIAL PROPERTY PRICE INDICATORS

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I. 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.

  →**MSCI-IPD or Investment Property Data Bank in UK**

- **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

Balanced panel of observations on **50 REITs (Properties)** for **22 quarters**, starting in Q1 of 2007 and ending in Q2 of 2012.

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)** $\mathbf{P_A^t \equiv \sum_{n=1}^{50} P_{tn} Q_{1n} / \sum_{n=1}^{50} P_{1n} Q_{1n} = \sum_{n=1}^{50} V_{tn} / \sum_{n=1}^{50} V_{1n}}$;

- $t = 1,\ldots,22.$

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.

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}.

a) b) c)

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

A) 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) $\mathbf{V_{Ltn} = P_{Ltn}Q_{Ltn}\ ;\ Q_{Ltn} = L_{tn} = L_n}$; $\qquad$ $n = 1,\ldots,50\ ;\ t = 1,\ldots,22$

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).

B) THE *VALUE OF THE STRUCTURE* ON THE PROPERTY, V_{STN}

(4) $V_{Stn} = .3P_{St}S_{tn}(1-\delta_S)^{A(t,n)}$; $\quad n = 1,\ldots,50$; $t = 1,\ldots,22$

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.

C) 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:

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

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:

$$\textbf{(7)}\ \mathbf{q_{CEn}} \equiv \textstyle\sum_{t=1}^{22} \mathbf{q_{CEtn}/22}\ ;\ n = 1,\ldots,50.$$

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:

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

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:

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

- 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) $\mathbf{V_{CEtn} \equiv P_{CEtn}Q_{CEtn}; P_{CEtn} \equiv P_{St}}$; $\quad t = 1,...,22$; $n = 1,...,50$

  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) $\mathbf{P_{Ltn} \equiv [V_{tn} - V_{Stn} - V_{CEtn}]/L_n}$; $\quad n = 1,...,50$; $t = 1,...,22$.

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 ($\mathbf{P_{Ltn}}$, $\mathbf{P_{Stn}}$ **and** $\mathbf{P_{CEtn}}$) and the corresponding quantities ($\mathbf{Q_{Ltn}}$, $\mathbf{Q_{Stn}}$ **and** $\mathbf{Q_{CEtn}}$).
- 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:

$$(12)\ V^t \equiv \sum_{n=1}^{50} V_{tn}\ ; \quad V_L^t \equiv \sum_{n=1}^{50} V_{Ltn}\ ;$$

$$V_S^t \equiv \sum_{n=1}^{50} V_{Stn}\ ; \quad V_{CE}^t \equiv \sum_{n=1}^{50} V_{CEtn}\ ; \qquad t = 1,\ldots,22.$$

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:

$$(13)\ P_{L,Land}{}^{t-1.t} \equiv \sum_{n=1}^{50} P_{Ltn}Q_{L,t-1,n}/\sum_{n=1}^{50} P_{L,t-1,n}Q_{L,t-1,n}\ ; \quad t = 2,3,\ldots,22.$$

- The above chain links are used in order to define the *overall* ***Laspeyres land price indexes***, $P_{L,Land}{}^{t}$, as follows:

$$(14)\ P_{L,Land}{}^{1} \equiv 1\ ;\ P_{L,Land}{}^{t} \equiv P_{L,Land}{}^{t-1}\ P_{L,Land}{}^{t-1,t}\ ; \quad t = 2,3,\ldots,22.$$

- 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:

$$\textbf{(15)}\ P_{P,Land}^{t-1.t} \equiv \sum_{n=1}^{50} P_{Ltn}Q_{Ltn}/\sum_{n=1}^{50} P_{L,t-1,n}Q_{Ltn}\ ;\quad t = 2,3,\ldots,22.$$

- The above chain links are used in order to define the overall Paasche land price indexes, $P_{P,Land}^{t}$, as follows:

$$\textbf{(16)}\ P_{P,Land}^{1} \equiv 1\ ;\ P_{P,Land}^{t} \equiv P_{P,Land}^{t-1}\ P_{P,Land}^{t-1,t}\ ;\quad t = 2,3,\ldots,22.$$

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

$$(17)\ P_{F,Land}{}^{t} \equiv [P_{L,Land}{}^{t}\, P_{P,Land}{}^{t}]^{1/2}\ ; \qquad t = 1,\ldots,22.$$

- **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). [For land, Fisher = Laspeyres = Paasche]

THE OVERALL PROPERTY PRICE INDEX

- Finally, an *overall chained Fisher property price index*, P_F^t, can be constructed in the same way except that the summations in the numerators and denominators of (13) and (15) above sum over 150 separate price components (all of the P_{Ltn}, P_{Stn} and P_{CEtn}) instead of just 50 price components.
- The Fisher price indexes P_F^t, $P_{F,Land}^t$, $P_{F,S}^t$ and $P_{F,CE}^t$ are listed in Table A1 in the Appendix, except that we dropped the subscript F; i.e., in what follows, denote these series by P^t, P_L^t, P_S^t and P_{CE}^t respectively.

CHAINED FISHER PROPERTY QUANTITY INDEXES

- 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) $$\mathbf{Q^t \equiv V^t/P^t\,; \qquad Q_L{}^t \equiv V_L{}^t/P_L{}^t\,; \qquad Q_S{}^t \equiv V_S{}^t/P_S{}^t\,;}$$

$$\mathbf{Q_{CE}{}^t \equiv V_{CE}{}^t/P_{CE}{}^t\,; \qquad\qquad t = 1,\ldots,22.}$$

- 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, $Q_S{}^t$ is an estimate of the aggregate real structure stock for the REITs and $Q_{CE}{}^t$ is an estimate of the real stock of capital improvements made by the REITs since they were constructed up to time t.

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:

$$\textbf{(19)}\ \mathbf{Q_S^t = V_S^t/P_{St};\ Q_{CE}^t = V_{CE}^t/P_{St}\ ;\qquad t = 1,\ldots,22.}$$

- The overall REIT price index $\mathbf{P^t}$ (**P**) is charted on the next slide along with the corresponding aggregate land and structure price indexes, $\mathbf{P_{Lt}}$ and $\mathbf{P_{St}}$ (**PS** and **PL**).
- An **asset value index** **PA** is also charted; this is simply the sum of the 50 quarter t REIT asset values divided by the quarter 1 asset values. (This index is similar to a ***repeat sales index*** in that it does not take into account CE and depreciation.)

- Note that **PA** has a small upward bias relative to **P**.

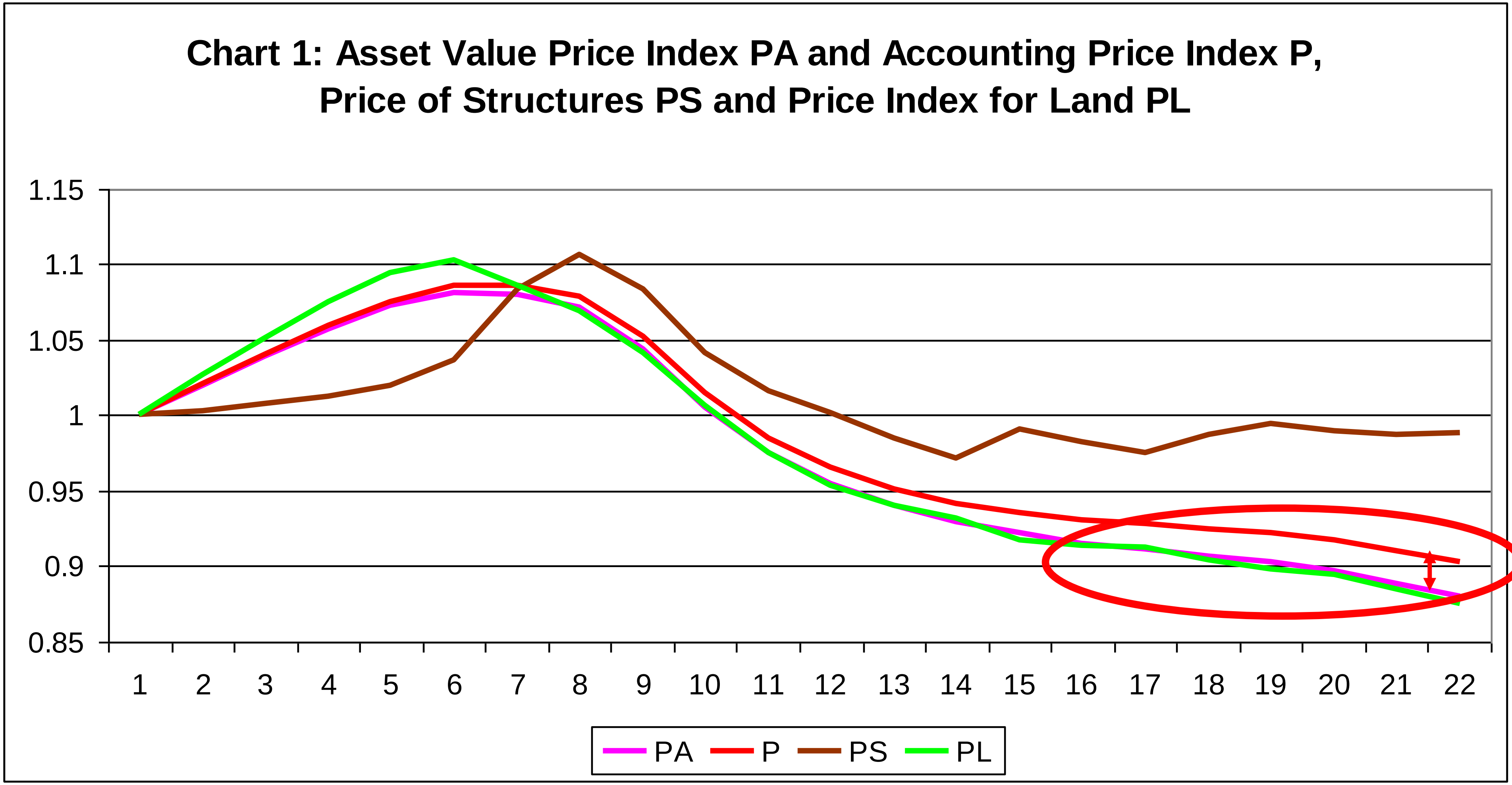
Chart 1: Asset Value Price Index PA and Accounting Price Index P,
Price of Structures PS and Price Index for Land PL
1.15
1.1
1.05
1
0.95
0.9
0.85
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
PA
P
PS
PL

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) $$\ln V_{tn} = \alpha + \alpha_t + \beta \ln L_{tn} + \gamma \ln S_{tn} + \delta A_{tn} + \varepsilon_{tn}$$

where $\alpha_1,\ldots,\alpha_{22}$, 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) $P_1^t \equiv \exp[\alpha_t]$; $t = 1,....,22$.

- The resulting overall commercial property price indexes generated by Hedonic Model 1, the P_1^t, will be shown on Chart 2 below.

SECOND TIME DUMMY HEDONIC REGRESSION MODEL

- The second time dummy hedonic regression model is defined for t = 1,...,22 and n = 1,...,50 by the following equations:

(23) $\ln V_{tn} = \alpha + \alpha_t + \beta \ln L_{tn} + \gamma \ln S_{tn} + \delta A_{tn} + \omega_n + \varepsilon_{tn}$

- 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. Note that we have introduced **property dummy variable parameters**, the ω_n, into the regression model.
- However, there is now exact collinearity in the above model so on the following slide, we modify the above model.

SECOND TIME DUMMY HEDONIC MODEL

- We drop the land variable (since it is constant for each property and hence collinear with the property dummy variables) and 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:

$$\textbf{(24)}\ \ln V_{tn} = \alpha_t + \omega_n + \delta \ln A_{tn} + \varepsilon_{tn}\ ; \quad t = 1,\ldots,22\ ;\ n = 1,\ldots,50.$$

- Equations (24) and (21) ($\alpha_1 = 0$) 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) $\mathbf{P_2^t \equiv \exp[\alpha_t]}$; $\quad\quad$ **t = 1,....,22**.

- These indexes **P2** are shown in Chart 2 below.
- When we set the age parameter δ equal to 0, we obtain **Model 3**, which turns out to be identical to the time series counterpart to Summer's **Country Product Dummy Model**.
- We estimated Model 3 as well and the resulting overall price indexes **P3** are also shown on Chart 2.
- Note that P3 is virtually identical to the asset value index PA and that P1 and P2 have severe downward biases relative to P.

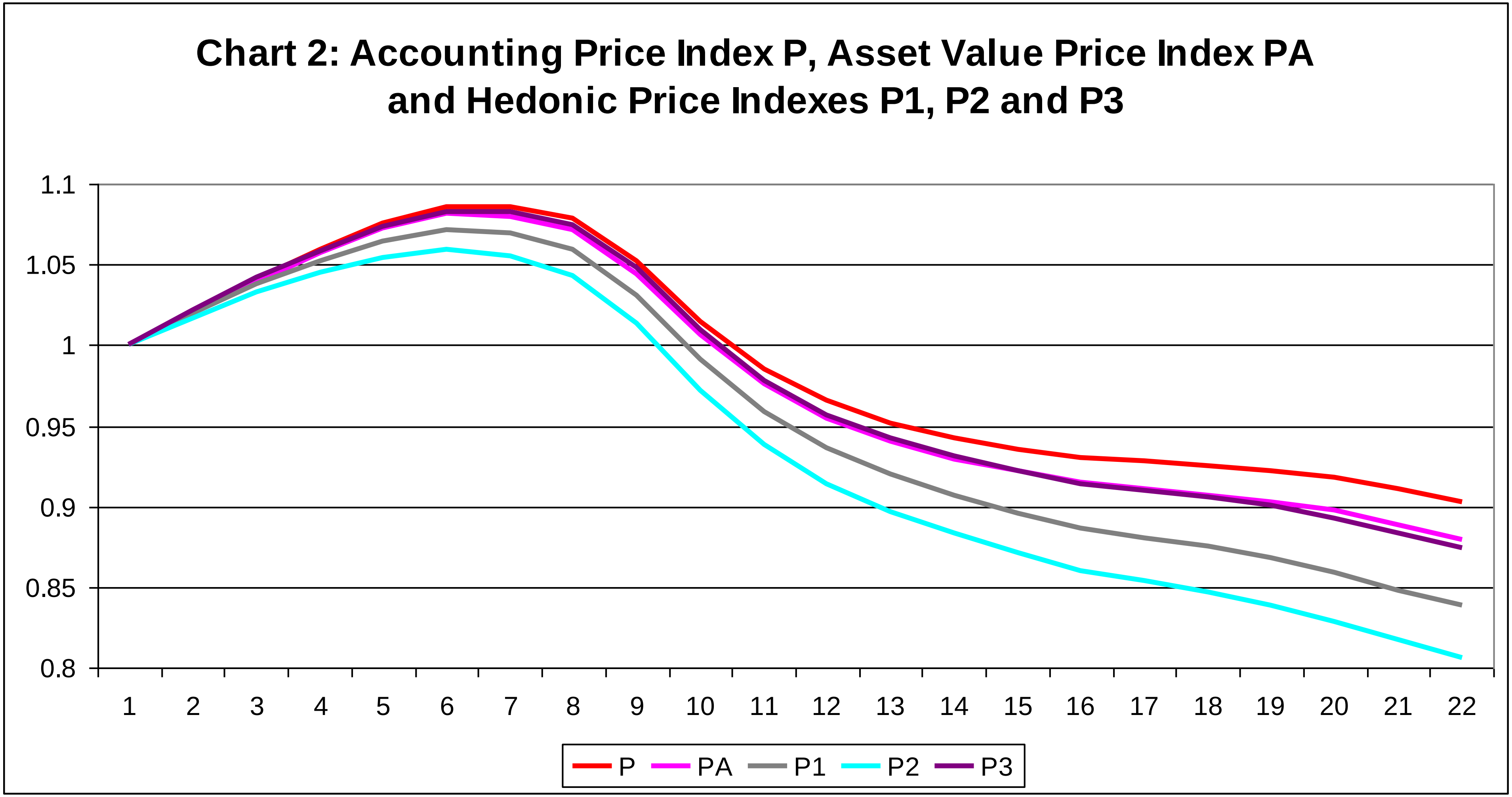
Chart 2: Accounting Price Index P, Asset Value Price Index PA and Hedonic Price Indexes P1, P2 and P3
1.1
1.05
1
0.95
0.9
0.85
0.8
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
P
PA
P1
P2
P3

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, β_t say, plus the cost of the land, which will be equal to the land cost per square meter, γ_{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, $\beta_t S_{tn} + \gamma_{tn} L_{tn}$.

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. γ_{tn} is the price of land in quarter t for REIT n.
- What about capital expenditures? We replace the assessed value $\mathbf{V_{tn}}$ by $\mathbf{V_{tn} - V_{CEtn}}$ where $\mathbf{V_{CEtn}}$ is the capital expenditures stock that we constructed earlier (mostly by assumption!).

THE COUNTRY PRODUCT DUMMY METHODOLOGY

- Thus we use a hedonic regression to decompose $V_{tn} - V_{CEtn}$ into structure and land components.
- There are too many land price parameters γ_{tn} to estimate. We deal with this 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

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

where α_t is an overall price of land for all 50 REITs in quarter t and ω_n is a quality of land adjustment factor for REIT n.

HEDONIC REGRESSION MODEL 4

- We also set the new structure prices for each quarter t, β_t, equal to a single price of structures in quarter 1, say β, times our official construction cost index $P_S{}^t$ described in earlier sections. Thus we have:

$$\textbf{(28)}\ \beta_t = \beta P_S{}^t\ ; \qquad\qquad t = 1,\ldots,22.$$

- Replacing V_{tn} by $V_{tn} - V_{CEtn}$ and substituting (27) and (28) into the modified equations (26) leads to the following nonlinear regression model:

$$\textbf{(29)}\ V_{tn} - V_{CEtn} = \beta P_S{}^t S_{tn}[e^{\phi}]^{A(t,n)} + \alpha_t \omega_n L_{tn} + \varepsilon_{tn}\ ;$$

$$t = 1,\ldots,22;\ n = 1,\ldots,50.$$

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^*, $\alpha_1{}^* \equiv 1$, $\alpha_2{}^*,\ldots,\alpha_{22}{}^*$, ϕ^* and $\omega_1{}^*,\ldots,\omega_{50}{}^*$. Note: the estimated depreciation rate turned out to be close to 0.5 % per quarter!
- 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:

$$\textbf{(30)}\ V_{S4tn}{}^* \equiv \beta^* P_S{}^t S_{tn}[e^{\phi^*}]^{A(t,n)}\ ;$$

$$\textbf{(31)}\ V_{L4tn}{}^* \equiv \alpha_t{}^* \omega_n{}^* L_{tn}.$$

STRUCTURE AND LAND VALUES

- 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:

$$\textbf{(32)}\ V_{S4t}^* \equiv \sum_{n=1}^{50} [V_{S4tn}^* + V_{CEtn}]\ ; \qquad t = 1,\ldots,22.$$

- 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:

$$\textbf{(33)}\ V_{L4t}^* \equiv \sum_{n=1}^{50} V_{L4tn}^*\ ; \qquad t = 1,\ldots,22.$$

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) $Q_{S4t}^{*} \equiv V_{S4t}^{*}/P_{S}^{t}$; $\quad t = 1,\ldots,22$;

(35) $Q_{L4t}^{*} \equiv V_{L4t}^{*}/P_{L4}^{t}$; $\quad t = 1,\ldots,22$.

- 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 below shows the resulting overall Fisher Property Price Index P4 (it is virtually identical to our SNA property price index P) along with the Asset Value Index PA (slight downward bias) and a final hedonic regression model based index P5.

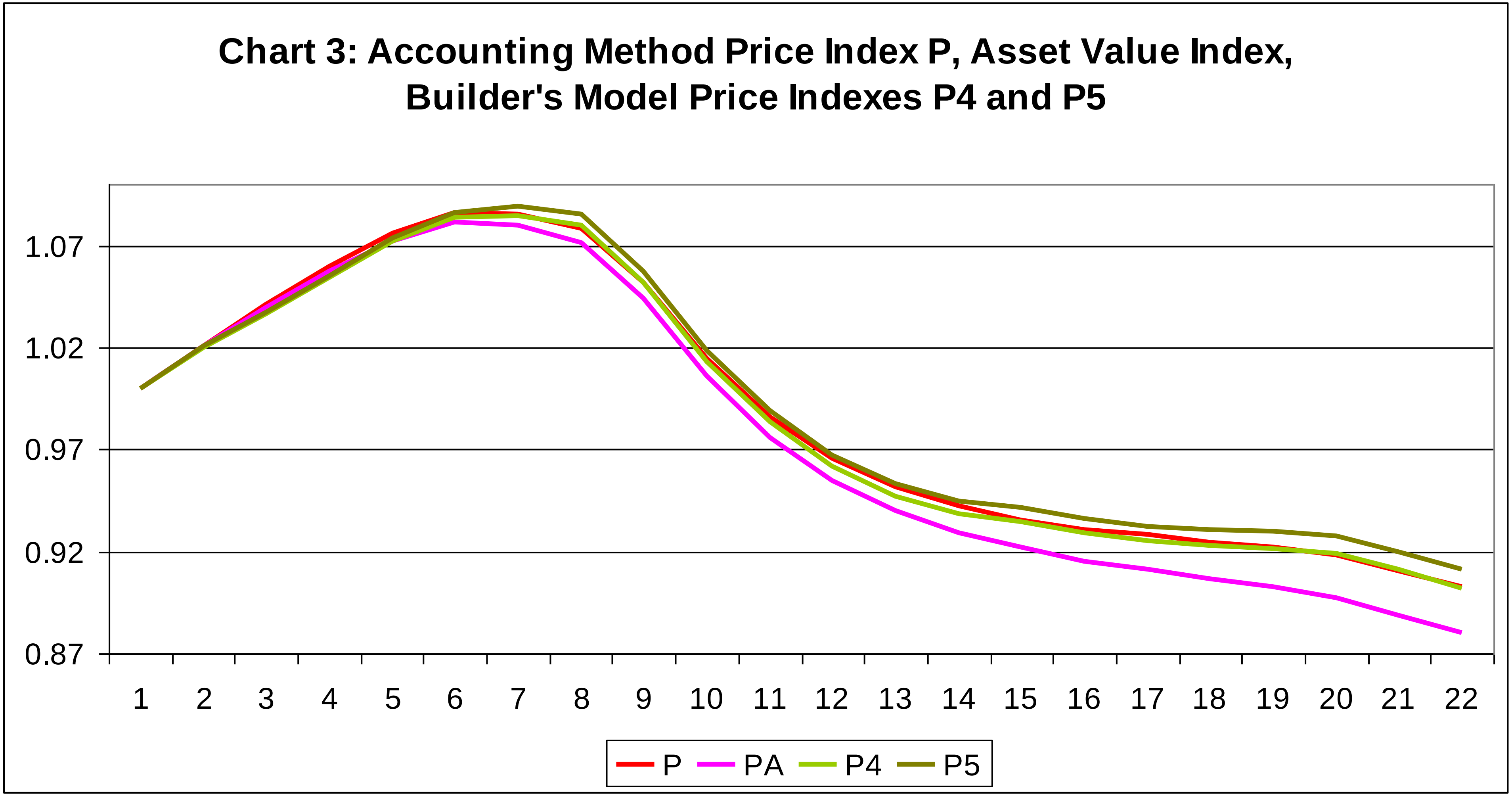

Chart 3: Accounting Method Price Index P, Asset Value Index,
Builder's Model Price Indexes P4 and P5
1.07
1.02
0.97
0.92
0.87
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
P
PA
P4
P5

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:

$$(38)\ \delta_i \equiv 1 - \exp[\phi_i]\ ; \qquad i = 1,2,3.$$

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:

$$\textbf{(39)}\ V_{tn} - V_{CEtn} = \beta P_S{}^t S_{tn} g(A_{tn}) + \alpha_t \omega_n L_{tn} + \varepsilon_{tn}\ ;$$

$$t = 1,\ldots,22;\ \ n = 1,\ldots,50$$

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

NEW REGRESSION MODEL: RESULTS

- The R^2 between the observed variables and the predicted variables turned out to be 0.9946. (R^2 for Model 4= 0.9943).
- The estimated ϕ_i parameters turned out to be –0.00328, –0.00705 and –0.03623 and the corresponding quarterly depreciation rates are δ_1 = 0.00327(first 20 years of building life), δ_2 = 0.00702 (next 10 years) and δ_3 = 0.03558 (remaining life).
- The single quarterly geometric depreciation rate from Model 4 was 0.00514.
- Chart 4 below shows the Model 4 and 5 land price indexes PL4 and PL5 along with PL, the land price index from our SNA based initial model. PL5 is slightly above PL4 and PL.

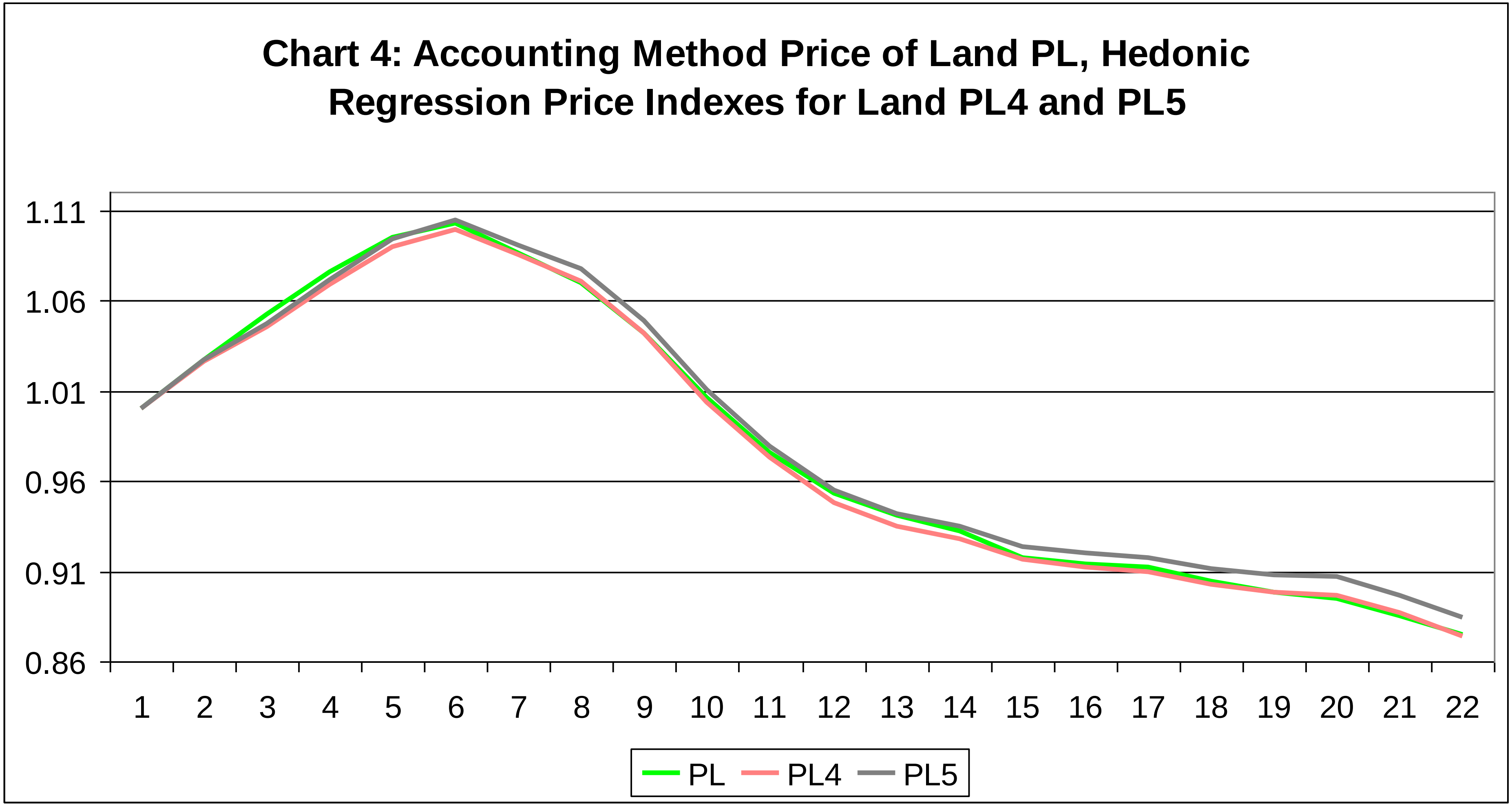
Chart 4: Accounting Method Price of Land PL, Hedonic Regression Price Indexes for Land PL4 and PL5
1.11
1.06
1.01
0.96
0.91
0.86
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
PL
PL4
PL5

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.**

→

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

Thank you!

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