Commercial Property Price Indexes for Tokyo

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Discussion Paper 17-04,
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Abstract

The SNA (System of National Accounts) requires separate estimates for the land and structure components of a commercial property. Using transactions data for the sales of office buildings in Tokyo, a hedonic regression model (the Builder's Model) was estimated and this model generated an overall property price index as well as subindexes for the land and structure components of the office buildings. The Builder's Model was also estimated using appraisal data on office building REITs for Tokyo. These hedonic regression models also generate estimates for net depreciation rates which can be compared. Finally, the Japanese Ministry of Land, Infrastructure, Transport and Tourism constructs annual official land price for commercial properties based on appraised values. The paper compares these official land prices with the land prices generated by the hedonic regression models based on transactions data and on REIT data. The results show that the Builder's Model can be used to estimate Tokyo office market indexes with a reasonable level of precision. The results also revealed that commercial property indexes based on appraisal and assessment prices lag behind the indexes based on transaction prices.

Key Words

Commercial property price indexes, System of National Accounts, the builder's model, transaction-based index, appraisal prices, assessment prices, land, and structure price indexes, hedonic regressions, depreciation rates.

Journal of Economic Literature Classification Numbers

C2, C23, C43, D12, E31, R21.

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1. Introduction

The formation and collapse of property bubbles have had a significant effect on the economic systems of many countries. The property bubbles that occurred in Japan during the 1980s and Scandinavian countries such as Sweden in the 1990s were triggered by soaring commercial property prices. A commercial property price bubble in the mid-1980s in the United States played a major role in that country's "Credit Crunch" of the late-1980s. As well, the heating up of the property investment market in the 2000s, especially in European countries, centered on commercial property. Given this, economic indexes that make it possible to properly capture trends in the commercial property market are needed in order to implement effective fiscal, economic, and financial policies. However, while there are some countries where commercial property price indexes and investment returns are published by the private sector, in most countries, statistical agency commercial property related statistics are not well developed.

The reasons for this lack of development are twofold: (i) commercial properties are very heterogeneous, and (ii) commercial properties do not transact very often. The single term "commercial property" covers a broad range of property, such as offices, retail facilities, investment housing, factories, distribution facilities, hotels, hospitals, care facilities. Moreover, there is considerable heterogeneity across metropolitan areas and geographic regions within countries, as well as striking heterogeneity at the individual asset level within each market segment or sector. Thus it is extremely difficult to compare "like with like" when constructing price indexes for commercial properties.

How, then, can commercial property price indexes be defined and measured? And what kind of relationship does the measurement of commercial property's value have to the System of National Accounts and to concerns about national financial sectors?

To address these issues, Diewert and Shimizu (2015a), and Diewert, Fox and Shimizu (2016) clarified the relationship between SNA and commercial property price indexes. Diewert and Shimizu (2016a) also proposed a measurement method using REIT data, which we will implement later in this paper.

When constructing price indexes, prices transacted on the market are generally used. However, in the creation of real estate price indexes - especially commercial real estate price indexes - it is not unusual for real estate appraisal values to be used, in part due to the low number of actual transactions. The MSCI IPD indexes, which supply property return (income return and capital return) indexes for 32 countries, are based on appraisal values. The NCREIF capital returns index - a leading U.S. real estate investment index - is also, like MSCI-IPD's index, a real estate investment capital returns index based on appraisal evaluation amounts.

In recent years, commercial price indexes based on transaction prices have also been published, such as the U.S. Moody's/RCA Commercial Property Price Index (CPPI) and the MIT/CRE Transaction Based Index (TBI). In addition, MSCI-IPD is developing a transaction price-based index. Thus, important points that arise with regard to the creation of commercial real estate price indexes are: (i) what are the underlying data (transaction, appraisal or assessment data) and (ii) how exactly are the indexes constructed?

The use of appraisal prices determined by specialists when attempting to estimate price indexes and measure market value in this way is, we believe, without equivalent in constructing economic statistics. That being the case, fully understanding the characteristics of appraisal prices is extremely important when it comes to measuring the market value of commercial property.

Focusing on the Tokyo office market, this paper examines two issues, i.e. the feasibility of implementing the Builder's Model proposed by Diewert and Shimizu (2015b), (2016b), and the issue of what difference does it make when different types of data are used to implement the model.

A primary objective of this study, which applies the Builder's Model to the Tokyo office market, is to extract land price indexes from the transaction prices compiled by the Japanese Ministry of Land, Infrastructure, Transport and Tourism. As mentioned above, a secondary objective is to compare commercial property price indexes according to the data source used. The data source options for commercial property price indexes are: transaction prices; appraisal prices compiled by real estate markets, e.g. the REIT market; and assessment prices for property tax purposes. This study will compare the resulting land price indexes using these 3 data sources.

The data are described in Section 2. The Builder's Model is explained in Section 3. The empirical results using transactions data are listed in Section 4 while the results using appraisal and assessment data are described in Section 5. The commercial land price indexes that result from the three approaches are also compared in Section 5.

Our conclusions are summarized in Section 6.

2. Data Description

When estimating commercial property price indexes, we are confronted with the following two problems: how to incorporate quality adjustments in the estimation method, and which data source to use in the estimation, i.e. the problem of data selection.

Research studies on commercial property price indexes have emphasized the problem of data selection when formulating indexes. Traditionally, transaction prices, i.e., market prices, have generally been used to estimate price indexes. However, the number of commercial property market transactions are extremely small. Furthermore, even if a sizable number of transaction prices can be obtained, the heterogeneity of the properties is so pronounced that it is difficult to compare like with like and thus the construction of reliable constant quality price indexes becomes very difficult.

Under such circumstances, many commercial property price indexes have been constructed using either appraisal prices from the real estate investment market, or using assessment prices for property tax purposes. The rationale for these price indexes is that, since appraisal prices and assessment prices for property tax purposes are regularly surveyed for the same commercial property, indexes based on these surveys hold most characteristics of the property constant[2], thus greatly reducing the heterogeneity problem as well as generating a wealth of data.

However, while appraisal prices look attractive for the construction of price indexes, they are somewhat subjective; i.e., exactly how are these appraisal prices constructed? Thus these prices lack the objectivity of market selling prices. Such considerations have led to the development of various arguments concerning the precision and accuracy of appraisal and assessment prices when used in measuring price indexes; see Shimizu and Nishimura (2006) on these issues. In particular, the literature on this issue has pointed out that an appraisal based index will typically lag actual turning points in the real estate market.[3] Geltner, Graff and Young (1994) clarified the structure of bias in the NCREIF Property Index, a representative U.S. index based on appraisal prices. In a later study, Geltner and Goetzmann (2000) estimated an index using commercial property transaction prices and demonstrated the magnitude of errors and the degree of smoothing in the NCREIF Property Index. These problems plague not only the NCREIF Property Index, but all indexes based on appraisal prices, including the MSCI-IPD Index.

With specific reference to Japan's real estate bubble period, Nishimura and Shimizu (2003), Shimizu and Nishimura (2006) (2007), and Shimizu, Nishimura and Watanabe (2012) estimated hedonic price indexes based on commercial property and residential housing transaction price based indexes and contrasted them with appraisal price based indexes and statistically laid out their differences. An examination of the estimated results revealed that during the bubble period, when prices climbed dramatically, indexes based on appraisal prices did not catch up with transaction price increases. Similarly, during the period of falling prices, appraisal based indexes did not keep pace with the decline in prices.

Furthermore, in the case of appraisal prices for investment properties, a systemic factor of appraiser incentives emerges as an additional problem. This problem differs intrinsically from the lagging and smoothing problems that arise in appraisal based methods. Specifically, the incentive problem involves inducing higher valuations from appraisers

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[2] Two important characteristics which are not held constant are the age of the structure and the amount of capital expenditures on the property between the survey dates.

[3] Another problem with appraisal based indexes is that they tend to be smoother than indexes that are based on market transactions. This can be a problem for real estate investors since the smoothing effect will mask the short term riskiness of real estate investments. However, for statistical agencies, smoothing short term fluctuations will probably not be problematic.

in order to bolster investment performance; see Crosby, Lizieri and McAllister (2009) on this point.

In this connection, Bokhari and Geltner (2010) estimated a quality adjusted price index by running a time dummy hedonic regression using transaction price data. Geltner (1997) also used real estate prices determined by the stock market in order to examine the smoothing effects of the use of appraisal prices. Finally, Geltner, Pollakowski, Horrigan and Case (2010), Shimizu, Diewert, Nishimura and Watanabe (2015), Diewert and Shimizu (2016a) and Shimizu (2016) proposed various estimation methods for commercial property price indexes using REIT data.

This study compiled the following three types of micro-data relating to commercial properties in the Tokyo office market: (i) the transaction price data compiled by the Japanese Ministry of Land, Infrastructure, Transport and Tourism; (ii) the appraisal prices periodically determined in the Tokyo office REIT market; and (iii) the “official land prices” surveyed by the Japanese Ministry of Land, Infrastructure, Transport and Tourism since 1970. Official land prices are based on appraisals that are released on January 1st of each year. In Japan, asset taxes relating to land, such as inheritance taxes and fixed assets taxes, are assessed on the basis of these official land prices. Thus official land prices are considered as assessment data for tax purposes. As official land prices are exclusively based on surveys of land prices, they do not include structure prices.

Table 1. Variables from the Three Data Sources

Symbols	**Variables**	**Contents**	**Unit**
V	Price	Transaction Price and Appraisal price in Total	million yen
L	Total Land area	Land area of building	m^2
S	Total Floor space	Floor space of building.	m^2
A	Age of building at the time of transaction.	Age of building at the time of transaction/appraisal	year
H	Number of stories	Number of stories in the building	stories
DS	Distance to the nearest station	Distance to the nearest station.	meter
TT	Travel time to central business district	Minimum railway riding time in daytime to Tokyo Station.	minute
WD_k (k=0,…,K)	Location(Ward) dummy	*k th aare* =1, other *district* =0.	(0,1)
D_t (t=0,…,T)	Time dummy (quarterly)	*t th quarter* =1, other *quarter* =0.	(0,1)

Using the first two data sources, land price indexes were estimated using the Builder's Model. These land price indexes will be compared with those estimated using official land prices in Section 5 of the paper.

Our analysis covers the period from 2005 to 2015. The data variables compiled are listed in Table 1.

Table 2 shows a summary of the statistical parameters for the 3 data sources, i.e. transaction prices, REIT appraisal prices, and official land prices. The compiled data consisted of 1,968 transaction prices, 1,804 REIT prices, and 6,242 official land prices.

Table2. Summary Statistics

	MLIT	REIT	PLP
V : Selling Price of Office Building	419.26	6686.60	416.88
	(368.75)	(4055.60)	(1036.40)
P: Unit Price	1.75	4.58	1.26
	(1.33)	(2.26)	(1.30)
S : Total Structure Floor Area (square metre)	903.30	8509.70	-
	(681.68)	(5463.90)	
L : Total Land Area (m^2)	254.24	1802.10	229.94
	(160.72)	(1580.20)	(217.18)
H : Total Number of Stories	5.79	10.12	-
	(2.17)	(3.30)	
A : Age (year)	24.32	19.14	-
	(10.67)	(6.80)	
DS : Distance to Nearest Station	387.61	308.29	347.24
	(237.73)	(170.04)	(254.79)
TT : Time to Tokyo	19.65	15.88	21.74
	(8.24)	(5.10)	(8.54)
PS : Construction Structure Price	23.47	23.59	-
	(1.03)	(1.02)	
Number of Observations	1,968	1,804	6,242

( ): Standard deviation

3. The Builder's Model

The *builder's model* for valuing a commercial property postulates that the value of a commercial property is the sum of two components: the value of the land which the structure sits on plus the value of the commercial structure.

In order to justify the model, consider a property developer who builds a structure on a particular property. The total cost of the property after the structure is completed will be equal to the floor space area of the structure, say S square meters, times the building cost per square meter, β_t during quarter or year t, plus the cost of the land, which will be equal to the cost per square meter, α_t during quarter or year t, times the area of the land site, L. Now think of a sample of properties of the same general type, which have prices or values V_{tn} in period t[4] and structure areas S_{tn} and land areas L_{tn} for n = 1,...,N(t) where N(t) is the number of observations in period t. Assume that these prices are equal to the sum of the land and structure costs plus error terms ε_{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 α_t and β_t are the parameters to be estimated in the regression:[5]

(1) $V_{tn} = \alpha_t L_{tn} + \beta_t S_{tn} + \varepsilon_{tn}$; $\quad t = 1,...,44;\ n = 1,...,N(t).$

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 α_t and the price of a square meter of structure floor space β_t.

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 A(t,n), and assuming a geometric (or declining balance) depreciation model, a more realistic hedonic regression model than that defined by (1) above is the following *basic builder's model*:[6]

(2) $V_{tn} = \alpha_t L_{tn} + \beta_t(1 - \delta_t)^{A(t,n)} S_{tn} + \varepsilon_{tn}$; $\quad t = 1,...,44;\ n = 1,...,N(t)$

where the parameter δ_t reflects the *net geometric depreciation rate* as the structure ages one additional period. Thus if the age of the structure is measured in years, we would

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[4] The period index t runs from 1 to 44 where period 1 corresponds to Q1 of 2005 and period 44 corresponds to Q4 of 2015.

[5] Other papers that have suggested hedonic regression models that lead to additive decompositions of property values into land and structure components include Clapp (1980; 257-258), Bostic, Longhofer and Redfearn (2007; 184), Diewert (2007; 19-22) (2010) (2011), Francke (2008; 167), Koev and Santos Silva (2008), Rambaldi, McAllister, Collins and Fletcher (2010), Diewert, Haan and Hendriks (2011) (2015) and Diewert and Shimizu (2015b) (2016a) (2016b).

[6] This formulation follows that of Diewert (2010) (2011), Diewert, Haan and Hendriks (2011) (2015), Eurostat (2013) and Diewert and Shimizu (2015b) (2016a) (2016b) in assuming property value is the sum of land and structure components but movements in the price of structures are proportional to an exogenous structure price index. This formulation is designed to be useful for national income accountants who require a decomposition of property value into structure and land components. They also need the structure index which in the hedonic regression model to be consistent with the structure price index they use to construct structure capital stocks. Thus the builder's model is particularly suited to national accounts purposes.

expect an annual *net* depreciation rate to be between 2 to 3%.[7] Note that (2) is now a nonlinear regression model whereas (1) was a simple linear regression model. The period t constant quality price of land will be the estimated coefficient for the parameter α_t and the price of a unit of a newly built structure for period t will be the estimate for β_t. The period t quantity of land for commercial property n is L_{tn} and the period t quantity of structure for commercial property n, expressed in equivalent units of a new structure, is $(1 - \delta_t)^{A(t,n)}S_{tn}$ where S_{tn} is the space area of commercial property n in period t.

Note that the above model is a *supply side model* as opposed to the *demand side model* of Muth (1971) and McMillen (2003). Basically, we are assuming competitive suppliers of commercial properties so that initially,[8] we are in Rosen's (1974; 44) Case (a), where the hedonic surface identifies the structure of supply. This assumption is justified for the case of newly built offices but it is less well justified for sales of existing commercial properties.

There is a major problems with the hedonic regression model defined by (2): The multicollinearity problem. Experience has shown that it is usually not possible to estimate sensible land and structure prices in a hedonic regression like that defined by (2) due to the multicollinearity between lot size and structure size.[9] Thus in order to deal with the multicollinearity problem, we draw on *exogenous information* on the cost of building new commercial properties from the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and we assume that the price of new structures is proportional to an official measure of commercial building costs, p_{tS}. Thus we replace β_t in (2) by p_{tS} for t = 1,...,44. This reduces the number of free parameters in the model by 44.

In order to get preliminary land price estimates, we replaced the structure term $\beta_t(1 - \delta_t)^{A(t,n)}S_{tn}$ in equations (2) by $p_{tS}(1 - 0.025)^{A(t,n)}S_{tn}$; i.e., we assumed that the annual geometric depreciation rate δ_t was equal to 0.025. The resulting linear regression model becomes the model defined by (3) below:

$$(3)\ V_{tn} = \alpha_t L_{tn} + p_{St}(1 - 0.025)^{A(t,n)}S_{tn} + \varepsilon_{tn}\ ; \qquad t = 1,...,44;\ n = 1,...,N(t).$$

We temporarily put aside the problem of jointly determining land and structure value to concentrate on determining sensible constant quality land prices. Once sensible land

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[7] This estimate of depreciation is regarded as a *net depreciation rate* because it is equal to a "true" gross structure depreciation rate less an average renovations appreciation rate. Since we do not have information on renovations and major repairs to a structure, our age variable will only pick up average gross depreciation less average real renovation expenditures.

[8] In later sections of the paper, we will see that purchasers of commercial propertiess also influence the price of a commercial properties.

[9] See Schwann (1998) and Diewert, de Haan and Hendriks (2011) and (2015) on the multicollinearity problem.

prices have been determined, we will then return to the problem of simultaneously determining land and structure values and constant quality price indexes. Thus we temporarily assume that the structure value for unit n in period t, V_{Stn}, is defined as follows:

$$(4)\ V_{Stn} \equiv p_{St}(1 - 0.025)^{A(t,n)}S_{tn}\ ; \qquad t = 1,...,44;\ n = 1,...,N(t).$$

Once the imputed value of the structure has been defined by (4), we define the imputed land value for commercial property n in period t, V_{Ltn}, by subtracting the imputed structure value from the total value of the commercial property, which is V_{tn}:

$$(5)\ V_{Ltn} \equiv V_{tn} - V_{Stn}\ ; \qquad t = 1,...,44;\ n = 1,...,N(t).$$

Thus we temporarily use V_{Ltn} as our dependent variable and we will attempt to explain variations in these imputed land values in terms of the property characteristics. We start our estimation procedure by estimating the following basic model:

Base Model:

$$(6)\ V_{Ltn} = \alpha_t L_{tn} + \varepsilon_{tn}\ ; \qquad t = 1,...,44;\ n = 1,...,N(t).$$

In order to take into account possible neighbourhood effects on the price of land, we introduce *ward dummy variables*, $D_{W,tn,j}$, into the hedonic regression (6). There are 23 wards in Tokyo special district. We combined several wards to one ward and made 14 wards or locational dummies.[10] These 14 dummy variables are defined as follows: for t = 1,...,44; n = 1,...,N(t); j = 1,...,14.

$$(7)\ D_{W,tn,j} \equiv 1 \text{ if observation n in period t is in Ward j of Tokyo;}$$

$$\equiv 0 \text{ if observation n in period t is } \textit{not} \text{ in Ward j of Tokyo.}$$

We now modify the model defined by (6) to allow the *level* of land prices to differ across the Wards. The new nonlinear regression model is the following one:[11]

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[10] 1: Chiyoda(198), 2: Chuo(237), 3: Minato(212), 4: Shinjuku(207), 5: Bunkyo(100), 6: Taito(128), 7: Sumida(74), 8: Koto(51), 9: Shinagawa(72), 10: Meguro(31), 11: Ota(70), 12: Setagaya(68), 13: Shibuya(143), 14: Nakano(41), 15: Suginami(40), 16: Toshima(83), 17: Kita(31), 18: Arakawa(42), 19: Itabashi(35), 20: Nerima(42), 21: Adachi(20), 22: Katsushika(18), 23:Edogawa(25). We combined to 14 wards dummies; DW1: Chiyoda(198), DW2: Chuo(237), DW3: Minato(212), DW4: Shinjuku(207), DW5: Bunkyo(100),DW6:Taito(128),DW7:Sumida(74)+Koto(51)=(125),DW8: Shinagawa(72)+ Meguro(31) =(104),DW9:Ota(70) DW10: Setagaya(68), DW11: Shibuya(143), DW12: Nakano(41)+Suginami(40)=(81), DW13:Toshima(83)+Kita(31)=(114),DW14=Arakawa(42)+Itabashi(35)+Nerima(42)+ Adachi(20) + Katsushika(18) +Edogawa(25)=(182). Recall that there are 1968 observations in our sample.

[11] Our nonlinear regression models are *nested*; i.e., we use the coefficient estimates from the previous model as starting values for the subsequent model. Using this nesting procedure is essential to obtaining sensible results from our nonlinear regressions.

Model 1:Time Dummies + Ward Dummies

(8) $V_{Ltn} = \alpha_t(\sum_{j=1}^{14} \omega_j D_{W,tn,j})L_{tn} + \varepsilon_{tn}$; $t = 1,...,44$ $n = 1,...,N(t)$.

Comparing the models defined by equations (6) and (8), it can be seen that we have added an additional 14 *ward relative land value parameters*, $\omega_1,...,\omega_{14}$, to the model defined by (6). However, looking at (8), it can be seen that the 44 land price parameters (the α_t) and the 14 ward parameters (the ω_j) cannot all be identified. Thus we need to impose at least one identifying normalization on these parameters. We chose the following normalization:

(9) $\alpha_1 \equiv 1$.

The *footprint* of a building is the area of the land that directly supports the structure. An approximation to the footprint land for unit n in period t is the total structure area S_{tn} divided by the total number of stories in the structure TH_{tn}. If we subtract footprint land from the total land area, TL_{tn}, we get *excess land*,[12] EL_{tn} defined as follows:

(10) $EL_{tn} \equiv L_{tn} - (S_{tn}/TH_{tn})$; $t = 1,...,44$; $n = 1,...,N(t)$.

In our sample, excess land ranged from 1.0833 m^2 to 865.71 m^2. We grouped our observations into 3 categories, depending on the amount of excess land that pertained to each observation. Group 1 consists of observations tn where1: $EL_{tn} < 50$; 2: observations such that $50 \leq EL_{tn} < 125$; 3: $125 \leq EL_{tn}$. Now define the excess land dummy variables, $D_{EL,tn,m}$, as follows: for $t = 1,...,44$; $n = 1,...,N(t)$; $m = 1,...,3$:

(11) $D_{EL,tn,m} \equiv 1$ if observation n in period t is in excess land group m;

$\equiv 0$ if observation n in period t is *not* in excess land group m.

We will use the above dummy variables as adjustment factors to the price of land. A priori, we expected that an increase in the amount of excess land (holding constant other factors) would lead to an increase in the overall price of land per m^2 since more excess land should lead to better views and possibly more productivities for each commercial property and thus increase the price of land. In fact, the opposite happened; the more excess land a property possessed, the lower was the per meter squared value of land for that property.[13]

The new excess land regression model is the following one:

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[12] This is land that is usable for purposes *other* than the direct support of the structure on the land plot.

[13] The excess land characteristic was also used by Diewert and Shimizu (2016b) and Burnett-Isaacs, Huang and Diewert (2016) in their studies of condominium prices. The same phenomenon was observed in these studies: the more excess land that a high rise property had, the lower was the per meter land price.

Model 2:Model 1+ Splines on excessed land

(12) $V_{Ltn} = \alpha_t(\sum_{j=1}^{14} \omega_j D_{W,tn,j})(\sum_{m=1}^{3}\chi_h D_{EL,tn,m})L_{tn} + \varepsilon_{tn}$;

$t = 1,...,44; n = 1,...,N(t).$

However, looking at (11), it can be seen that the 44 land price parameters (the α_t), the 22 ward parameters (the ω_j) and the 3 excess land parameters (the χ_1) cannot all be identified. Thus we imposed the following identifying normalizations on these parameters:

(13) $\alpha_1 \equiv 1; \chi_1 \equiv 1.$

It is likely that the height of the building increases the value of the land plot supporting the building, all else equal. In our sample of commercial property prices, the height of the building (the H variable) ranged from 3 stories to 14 stories. There are a few observations in upper stories. We combined them and made 8 Hight dummies.[14] Thus we define the building height dummy variables, $D_{H,tn,h}$, as follows: for $t = 1,...,44$; $n = 1,...,N(t)$; $h = 3,...,14$:

(14) $D_{H,tn,h} \equiv 1$ if observation n in period t is in building height category h;

$\equiv 0$ if observation n in period t is *not* in building height category h.

The new nonlinear regression model is the following one:

Model 3:Model 2+ Height dummies

(15) $V_{Ltn} = \alpha_t(\sum_{j=1}^{14} \omega_j D_{W,tn,j}) (\sum_{m=1}^{5}\chi_h D_{EL,tn,m}) (\sum_{h=1}^{8} \mu_m D_{H,tn,h}) L_{tn} + \varepsilon_{tn}$;

$t = 1,...,44; n = 1,...,N(t).$

Comparing the models defined by equations (8) and (12), it can be seen that we have added an additional 8 *building height parameters*, $\mu_1,...,\mu_8$, to the model defined by (12).

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[14] H 3(361), H4(290), H5(348), H6(254), H7(229), H8(228), H9(155), H10(74), H11(19), H12(7), H13(2), H14(1). We combined to 10 Hight dummies; DH1=H 3(361), DH2=H4(290), DH3= H5(348), DH4=H6(254), DH5= H7(229), DH6= H8(228), DH7= H9(155), DH8=H10(74)+ H11(19)+ H12(7)+ H13(2)+ H14(1)=(103).

Not all of the parameters in (15) can be identified so we impose the following normalizations on the parameters in (15):

(16) $\alpha_1 \equiv 1$; $\chi_1 \equiv 1$; $\mu_1 \equiv 1$.

There are two additional explanatory variables in our data set that may affect the price of land. Recall that DS was defined as the distance to the nearest subway station and TT as the subway running time in minutes to the Tokyo station from the nearest station. DS ranges from 0 to 1,500 meters while TT ranges from 1 to 48 minutes. These new variables are inserted into the nonlinear regression model (15) in the following manner:

Model 4: Model3+DS(the distance to the nearest subway station)+TT(the subway running time in minutes to the Tokyo station from the nearest station):

(17) $V_{Ltn} = \alpha_t(\sum_{j=1}^{14} \omega_j D_{W,tn,j}) (\sum_{m=1}^{5}\chi_h D_{EL,tn,m}) (\sum_{h=1}^{10} \mu_m D_{H,tn,h})$

$\times(1+\eta(DS_{tn}-0))(1+\theta(TT_{tn}-1))L_{tn}+\varepsilon_{tn}$;

$t = 1,...,44; n = 1,...,N(t)$.

Not all of the parameters in (17) can be identified so we again impose the normalizations (16) on the parameters in (17):

Finally for our final builder's model for commercial property, we use V_{tn} as the dependent variable and use the same specification for the land component of the property that we used in Model 4 but now we add the term $(1 - \delta)^{A(t,n)}S_{tn}$ to account for the structure component of the value of the commercial property. Note that we will now estimate the annual depreciation rate δ in new model, rather than assuming that it was equal to 2.5%. Thus the number of unknown parameters in our new model increases from 69 to 70. Note that the normalizations (17) are still imposed on Model 5.

Model 5:Replace V_{Ltn} to V_{tn}.

(18) $V_{tn} = \alpha_t(\sum_{j=1}^{14} \omega_j D_{W,tn,j}) (\sum_{m=1}^{5}\chi_h D_{EL,tn,m}) (\sum_{h=1}^{10} \mu_m D_{H,tn,h})$

$\times(1+\eta(DS_{tn}-0))(1+\theta(TT_{tn}-1))L_{tn} + \beta_t(1 - \delta_t)^{A(t,n)}S_{tn} +\varepsilon_{tn}$;

$t = 1,...,44; n = 1,...,N(t)$.

4. Results using the Builder's Model with Transaction Prices

We started our estimation procedure by estimating Model 1. The normalization $\alpha_1 = 1$ is convenient since the resulting sequence of parameter estimates α_t will form an overall price index for commercial land in the 22 Wards where the index starts at unity in the first quarter of the sample period.

Taking into account the normalization (9), it can be seen that Model 1 defined by (8) has 44 unknown land price parameters α_t and 14 ward relative land price parameters ω_j. The regression model defined by (8) is now a nonlinear regression model. We estimated this model (and the subsequent nonlinear regression models) using the nonlinear regression option in Shazam; see White (2004). The R^2 for this model turned out to be 0.640 and the log likelihood (LL) was -13421.67.

In next step, we added the excess land dummy variables. The R^2 for Model 2 turned out to be 0.659 and the log likelihood was an increase of 48.62 over the final LL of Model 2 for the addition of 3 new parameters.

In Model 3,we added height of the building as in equations (15). The R^2 for Model 3 turned out to be 0.730 and the log likelihood was an increase of 237.01 over the final LL of Model 2 for the addition of 7 new parameters.

For Model 4, the distance to the subway parameter turns out to be $\eta^* = -0.0003$ ($t = -5.197$) so that an extra minute of distance reduces the land value component of the commercial property by 0.03%. The travel time to the Tokyo Central Station parameter is $\theta^* = -0.003$ ($t = -1.192$) so that an extra minute of travel time reduces the land value component of the commercial property by 0.3%. It can be seen that these two additional explanatory variables have explanatory power.

In the Model 5, we switch from imputed land value V_{Ltn} as the dependent variable in the regressions to the selling price of the property, V_{tn}. We use the estimated values for the coefficients in (21) as starting values in the nonlinear regression which follows.

Our new model uses V_{tn} as the dependent variable and uses the same specification for the land component of the property that we used in the Model1-4 but now we add the term $(1 - \delta)^{A(t,n)}S_{tn}$ to account for the structure component of the value of the commercial property. Note that we will now estimate the annual depreciation rate δ in our new model, rather than assuming that it was equal to 2.5%. Thus the number of unknown parameters in our new model increased from 80 to 81.

The R^2 for this new model turned out to be 0.734 and the log likelihood was -13122.71. This LL cannot be compared with the LL in the previous model, because the dependent variable has changed. The estimated depreciation rate was $\delta^* = 0.065$ ($t = 6.739$). This estimated annual depreciation rate of 6.5% is much higher than our earlier assumed rate of 2.5%. We will have to improve this model in future.

Table3. Estimated Results of Builder's Model for Transaction Prices in Tokyo

Estimation Method	NL				
Number of Observations	1,968				
Dependent Variable	PL				V
Model	Model.1	Model.2	Model.3	Model.4	Model.5
A : Depreciation rate	-	-	-	-	0.065
					(6.739)
DS:Distance to the nearest station (metre)	-	-	-	-0.0003	-0.0002
				-5.197	-4.972
TT:Time to the Tokyo station (minutes)	-	-	-	-0.003	-0.004
				(-1.192)	(-1.619)
D_{EL}: Effective Land Area GROUP DUMMY					
$D_{EL}1$: $EL < 50$	-	0.954	1.083	1.071	0.819
		(5.051)	(6.850)	(6.312)	(6.287)
$D_{EL}2$: $50 <= EL < 125$	-	0.749	0.428	3.548	0.349
		(3.527)	(3.307)	(3.548)	(3.469)
$D_{EL}3$: $125 <= EL$	-	0.303	0.316	0.348	0.264
		(4.746)	(4.649)	(4.957)	(4.774)
H: STORY GROUP DUMMY					
H=3	-	-	base line	base line	base line
D_H1: H=4			1.041	0.996	1.048
			(16.541)	(14.222)	(16.269)
D_H2: H=5			1.308	1.283	1.337
			(19.315)	(16.429)	(18.699)
D_H3: H=6			1.569	1.509	1.584

			(19.642)	(16.462)	(18.894)
D_H4: H=7			1.696	1.620	1.731
			(20.219)	(16.586)	(18.826)
D_H5: H=8			2.109	2.018	2.137
			(20.953)	(17.090)	(19.463)
D_H6: H=9			2.400	2.244	2.370
	-		(20.036)	(16.614)	(18.938)
D_H7: H>=10			2.454	2.335	2.496
	-		(19.652)	(16.372)	(18.686)
WD_k(Location dummy)	Yes				
Dt (Time dummy)	Yes				
R-SQUARE	0.640	0.659	0.730	0.733	0.734
LOG-LIKELIHOOD FUNCTION	-13421.67	-13373.05	-13136.04	-13373.05	-13122.71

( ): t-Value

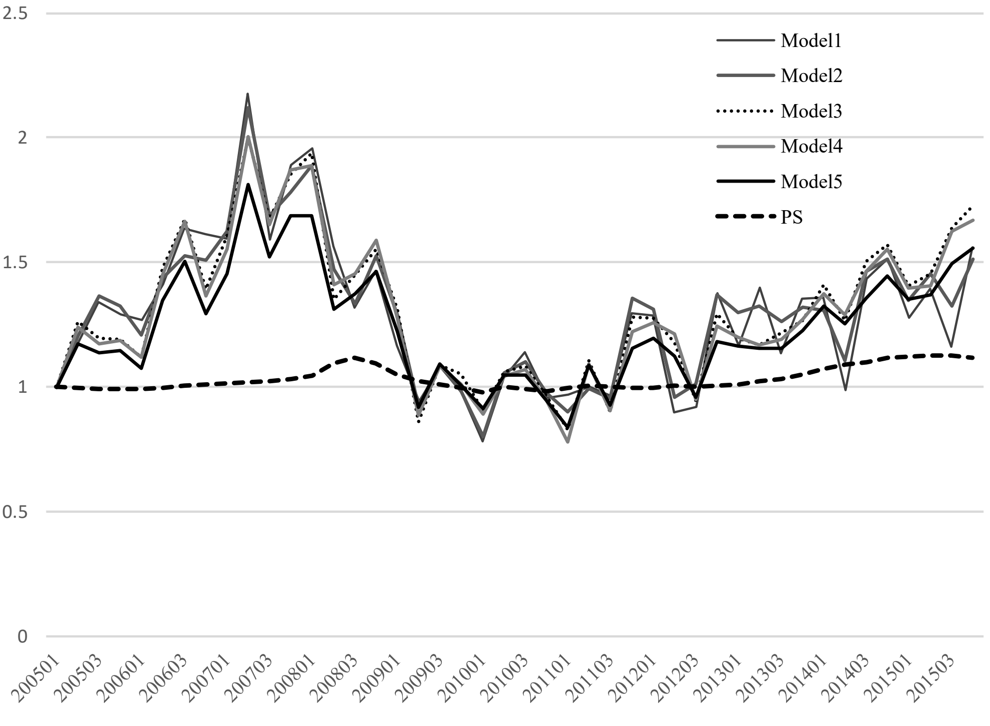

Figure 1. Quarterly Trends of PL and PS in Tokyo: Builder's Model

Using the estimated results, the land price index and structure price PS were compared. In the case of the land price index, we can trace the rise in 2006 and 2007 land prices mocked similarly with the investment fund bubble preceding the Lehman shock. We can also observe the fall in land prices accompanying the social disarray after the Great East Japan Earthquake of March 2011 and subsequently, the Fukushima Reactor No. 1 explosion.

Shifting our focus to more recent years, media reports have frequently highlighted capital flows into the real estate market accompanying the massive easing of financial liquidity since 2013 due to Abenomics, as reflected in the rise in land prices seen from 2013 to 2015. Subsequently, prices dipped for a while, but signs of a renewed uptick can be observed.

Meanwhile, also in the case of the structure price PS, substantial increases continue to be seen since 2013, due to construction demand brought about by the recovery from the Great East Japan Earthquake, as well as increasing development demands due to the upcoming 2020 Olympics. Property price increases in recent years can clearly be attributed to the combination of these two factors.

5. Comparison with Appraisal Prices and Assessment Prices

In this section, we apply the Builder’s Model to REIT data and time dummy hedonic model to official land prices, estimate the land price indexes, and compare the 3 indexes: transaction based land price index (MLIT), appraisal based land price index (REIT) and assessment based land price index (PLP). For the comparison of data sources, we note that the transaction price data are compiled monthly; the REIT appraisal price data are compiled monthly or quarterly; while the official land prices(PLP: Published Land Prices) are surveyed only once yearly. Hence, the transaction price data and REIT data are annualized for the purpose of comparison with the official land price index.

Since official land prices are based only on a survey of land prices, they do not incorporate structure prices. In our estimate of the land price index based on official land prices, the variables relating to structure in the Builder’s Model mentioned in the above section were excluded. Hence, strictly speaking, our model differs from the original Builder’s Model. Moreover, since this study’s objective is to compare price indexes according to the 3 data sources used, the descriptive variables in the 3 respective models were standardized to resemble each other as much as possible. The REIT model and the official land price model were then estimated. The estimated results are shown in Table 3.

The coefficient of determination adjusted for degrees of freedom was 0.725 for the transaction price model; 0.869 for the REIT model, and 0.857 for the official land price model (PLP). The depreciation rate was 2.8% for the transaction price model; 3.6% for the REIT model; and 2.5% for the quarterly model using previous transaction price data, a result consistent with other research on future prospects.

Table4. Estimated Results with Three Data Source in Tokyo

Estimation Method		NL	
DataSet	MLIT	REIT	PLP
Number of Observations	1,968	1,804	6,242
Dependent Variable	V	V	PL
A : Depreciation rate	0.067	0.036	
	(7.388)	(0.005)	
DS: Distance to the nearest station	-0.0002	0.0000	-0.0009
	-(5.689)	(0.000)	(0.000)
TT :Time to the Tokyo station	-0.004	-0.005	-0.022408
	-(2.125)	(0.002)	(0.001)
D_{EL}: Effective Land Area GROUP DUMMY			
$D_{EL}1$: EL < 50	0.885	Yes	-
	(6.685)		
$D_{EL}2$: 50 < =EL < 125	0.334	Yes	-
	(3.220)		
$D_{EL}3$: 125 <= EL	0.257	Yes	-
	(4.670)		
H: STORY GROUP DUMMY			
H=3	base line	base line (Different Scale)	
D_H1: H=4	1.039	Yes	-
	(15.635)		
D_H2: H=5	1.311	Yes	-
	(18.538)		
D_H3: H=6	1.595	Yes	-
	(19.003)		
D_H4: H=7	1.726	Yes	-
	(19.431)		
D_H5: H=8	2.096	Yes	-
	(20.195)		

$D_{H}6$: H=9	2.314 (19.067)	Yes	-
$D_{H}7$: H>=10	2.541 (19.173)	Yes	-
WD_k(Location dummy)	Yes		
Dt (Time dummy)	Yes		
R-SQUARE	0.728	0.869	0.857

( ): t-Value

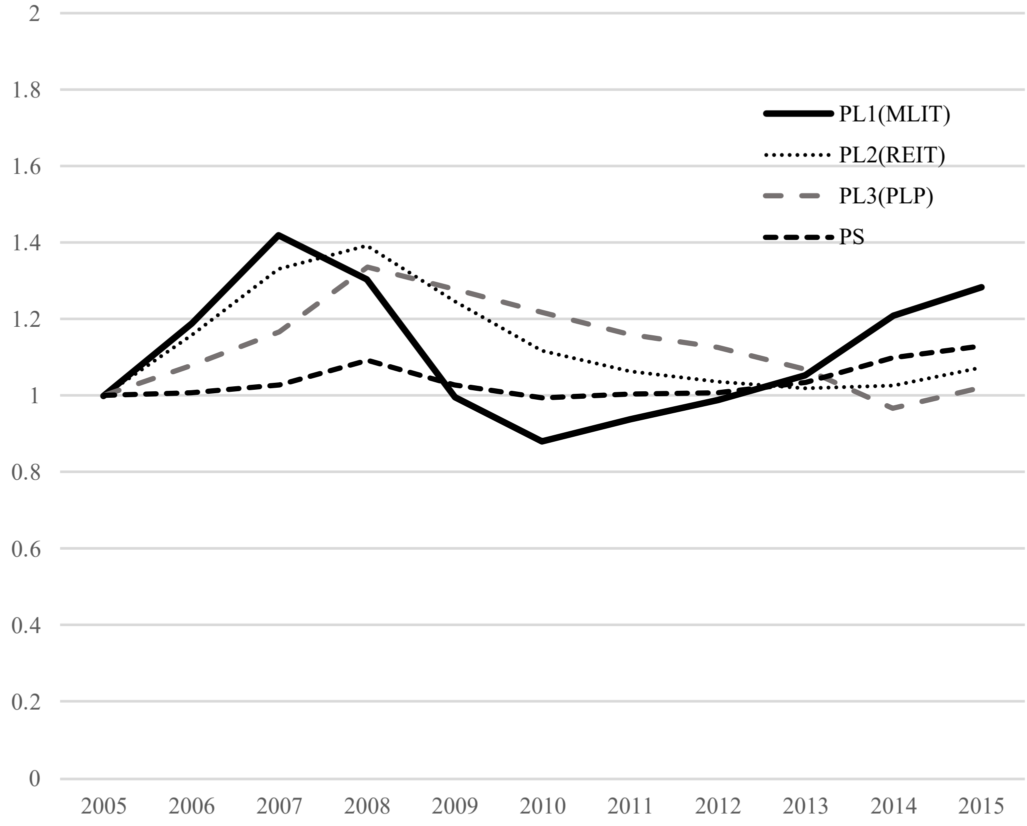

Figure 2. Comparison of PL's from Three Data Sources and PS in Tokyo

When the three indexes are compared in Figure 2, their particular characteristics can be visually grasped. Firstly, the structure price PS, as mentioned above, shows a decline that can be observed starting in 2012, following the Great East Japan Earthquake of 2011. However, prices started to rise substantially in 2013 when the massive easing of financial liquidity referred to as Abenomics began. This strong uptrend has been reinforced by increased construction demand from development projects linked to the upcoming 2020 Tokyo Olympics.

Viewed from the perspective of the transaction price-based index and the REIT index, land prices started to show signs of recovery in 2012. However, the index based on official land prices showed similar signs only later in 2014. Furthermore, starting from 2005 until the post-Lehman shock period of collapse, the transaction price-based index pointed to 2007 as the peak, while the REIT appraisal price-based index and the index based on official land prices showed 2008 instead, thus revealing a one-year lag.

6. Conclusions

The estimation of commercial property price indexes is ranked as one of the most difficult measurements in economic statistics. It is also one of the important components of SNA measurements. For this purpose, indexes that separate land from structure are necessary.

When actually measuring these indexes, the problem of selecting the estimation method and the data sources must be confronted. In the course of this study, the following conclusions were derived.

・It was demonstrated that the Builder’s Model proposed by Diewert and Shimizu (2005a), (2006a) as an estimation method for a commercial property price index that separates land from structure, can also be used with a certain level of precision in the office market, which is highly heterogeneous compared to the residential housing market.

・Aside from transaction prices, the data source options used are: appraisal prices obtained from the real estate investment market and assessment prices for property tax purposes. However, it was established that compared to transaction price-based indexes, those based on appraisal and assessment prices exhibit a certain degree of lagging.

Numerous problems still remain. In the realm of commercial properties, there are many other structures with diverse uses, e.g. commercial establishments, hotels, and warehousing & distribution facilities. In such markets, it is to be expected that transactions prices are even more scarce, and properties, even more heterogeneous, when compared to the office market. Furthermore, certain quantities of transaction price data and appraisal prices from the real investment market are available for use in large cities such as Tokyo. However, it is highly probable that sufficient data will be hard to come by in regional cities.

These are topics that we wish to explore in our future research endeavors.

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