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Imputed rent estimate of detached houses with regional characteristics and housing quality adjustments: A case study using Japan's housing and land survey data

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Imputed rent estimate of detached houses with regional characteristics and housing quality adjustments: A case study using Japan's housing and land survey data

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Abstract

The problem of imputed rent estimation in national accounts has been widely discussed among statisticians in Japan. The imputed rent of owner-occupied housing is estimated using prevailing rental prices. Thus, it is important to determine whether a more accurate quality adjustment would raise the estimated imputed rent of owner-occupied properties. This study examined the determinants of housing quality and developed an alternative estimation method for the imputed rent of owner-occupied detached houses. Specifically, we used a hedonic model to identify the regional characteristics and housing quality factors specific to individual houses that influence imputed rent estimation. Comparing our results to the current estimation results used in the Japanese Statement of National Accounts reveals that our imputed rent estimation results, which reflect regional characteristics and housing quality, are 3.84% higher than that estimated using the current methods. These findings highlight the need to incorporate a subdivision of the analysis area as well as the quality of city planning and housing into the imputed rent estimation method.

Keywords: Imputed rent, Hedonic model, Quality adjustment, Detached houses, System of National Accounts
JEL Classification: E01, R10, R32

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1. Introduction

The total value of imputed rent is incorporated into the Statement of National Accounts (SNA) and is a component of gross domestic product (GDP). Imputed rent is an estimate of the rent the owners would pay if they rented the properties they occupied. The estimation of this value does not use market prices per se; instead, imputed rent is valued by using the market prices of rental housing. The methodologies used to make such estimates are determined by each country's statistics bureau, following the recommendations of the United Nations (1977). There is no internationally standardized method for these estimates; instead, countries develop their own methods consistent with their unique situations. After adoption, countries will update their methods as their situations change.

The methodologies used in other countries' estimates are outlined in Eurostat-OECD (2012), Eurostat (2010), and Frick and Grabka (2002). In the United Kingdom, statisticians have also worked on improving methods for estimating imputed rent (Yu and Ive 2008) and the hedonic models used to adjust for housing quality (Richardson and Dolling 2005).

The Japanese SNA, which includes imputed rent, is estimated according to the Cabinet Office's "Explanatory Notes on the Methodology for Calculating the Statement of National Accounts"[1] (Cabinet Office 2011). However, it has been noted that the derived imputed rent neither reflects market prices nor considers regional characteristics or housing quality (e.g., Arai 2005). In light of these issues and in line with the 2008 United Nations recommendation (SNA2008; United Nations 2008), a discussion on an optimal estimation method for imputed rent, including the use of a hedonic model or a similar method, is required.

Based on a summary by Balcazar et al. (2017), two model approaches are used to estimate imputed rent based on actual conditions (a hedonic model and a non-hedonic model). The former uses current government statistical data, whereas the latter requires a re-evaluation of user costs (Yates 1994) or self-evaluation data (Fessler et al. 2016).

Furthermore, housing quality adjustment, which is promoted by SNA2008, needs to be discussed. As every house is different, Hill (2013) argues that we should account for these quality differences through housing price indexes. Housing quality adjustment methods include the hedonic model and repeat-sales method. Hill and Syed (2016), who used the hedonic model, found that the quality difference between owned and rented houses in Sydney was approximately 18%. In addition, Baltagi and Li (2015) confirmed the difference between owned and rented houses in Singapore using the repeat-sales method. However, the repeat-sales method is subject to methodological constraints, and the results can only be verified using data such as condominiums of similar quality.

To eliminate such constraints in the repeat-sales method, this study uses the hedonic model for housing quality adjustment in the estimation of imputed rent in the SNA. Although many studies on hedonic models for housing have been conducted (Chin and Chau 2003), there is no consensus on the specific form of the hedonic price function (Lisi 2013). Therefore, we empirically investigate the hedonic model for housing. Fujisawa et al. (2021) conducted an estimation analysis using the Housing and Land Survey data and confirmed the use of the hedonic model to estimate imputed rents for apartments and detached houses in Tokyo.

There are two main arguments to improve imputed rent estimation: the first is to propose a new imputed rent estimation method based on new data (e.g., Shimizu et al. 2009), and the second is to modify and improve the current situation (e.g., Fujisawa et al. 2021). This study is based on the latter, and we tried to estimate imputed rent of detached houses with strong individuality and then verify its feasibility using the method developed by Fujisawa et al. (2021).

The objective of this study is to introduce an alternative estimation method for detached houses that reflects housing market characteristics consistent with current estimation methods (current estimates) by utilizing Cabinet Office data (2011). Specifically, our study estimates imputed rents of detached houses that consider regional characteristics and housing quality and identifies differences

[1] An edition of the Explanatory Notes on the Methodology for Calculating the Statement of National Accounts is published for each base year in Japan; the most recent being the 2011 base year edition. In addition, annual estimates and quarterly preliminary GDP estimates (QE) differ, and editions are also published for annual and QE estimates. (Accessed: October 22, 2020) https://www.esri.cao.go.jp/jp/sna/data/reference1/sakusei_top.html.

from current imputed rent estimates. Subsequently, we propose an improved estimation method that adjusts for housing quality.

The remainder of this paper is organized as follows. Section 2 gives a brief overview of the existing issues and the proposed improvement to the imputed rent estimate in Japan. Section 3 describes the analytical method, the new estimation, and the data used in this study. Section 4 describes the results of the analysis and estimates. Based on the results, we discuss the estimation design for imputed rent. Finally, section 5 concludes this study and presents its key implications as an alternative of the imputed rent estimation method.

2. Existing issues and proposed improvement plan

2.1 Existing issues

The importance of imputed rent has been widely discussed among Japanese statisticians. Arai (2005) has pointed out that regional characteristics and housing quality are not taken into consideration and that, by their very nature, imputed rents are nationwide and subject to data limitations.

A problem with the current estimation method is failure to reflect market prices in imputed rent by using the continuous rent price in the estimation. This is highlighted by Shimizu et al. (2010), who note that the current estimate uses continuous rent data from the "Housing and Land Survey" of the Ministry of Internal Affairs and Communications (MIC), which differ from market rental price data. Dieweret and Shimizu (2016) investigated continuous rent and prepared estimates using private sector rental housing data. According to them, the trends in these indicators differ from the trends in imputed rents. Although this issue of continuous rent is significant, the immediate task is to adjust the quality of imputed rent to SNA2008.

Reflecting Arai (2005) pointed out, there was improvement in the estimation method from uniformly across a country to each prefecture by Japanese government. However, Shimizu et al. (2013) stated that it is impossible to determine the effects of various market characteristics on rent in current prefecture-level estimation. Thus, there is a need for a method for estimating imputed rents that is more realistic and considers both regional characteristics and housing quality.

2.2 Proposed improvement plan

Current imputed rent estimates differ in methodology depending on whether they are calculated in base or non-base years of the Housing and Land Survey. Estimates in the base year (base year estimates) are developed using Housing and Land Survey data on (1) prefecture, (2) house structure, (3) attributes of the period from housing completion (completion period classifications), and (4) total floor space of owner-occupied housing. Since the Housing and Land Survey only presents data in five-year intervals, estimations for non-base years need to be developed from other data sources. To create adjusted estimates that capture changes from base year estimates, sources such as the "Statistics of Housing Construction Starts" by the Ministry of Land, Transport and Tourism are used for the period between base years.

In this study, we examine the process of adjustment for "regional characteristics" and "housing quality" in base year estimates, which serve as the basis for the five-year estimates. If base year estimates can be made more accurately, the accuracy of the estimates for non-base years will consequently improve.

2.2.1 Issues with regional characteristics

The current method of calculating average rent per square meter—by dividing the rent by floor space in each prefecture and multiplying this by the total floor space of owner-occupied houses—neither distinguishes between commercial and residential areas nor adjusts for the quality of regional characteristics. In other words, it does not reflect "geographical neighborhoods" or "regional characteristics," as pointed out by Ptacek and Baskin (1996). As addressed in the analysis by Arévalo and Ruiz-Castillo (2006), geographical variables representing regional characteristics should be taken into account.

As regional attributes in a single prefecture cannot be expressed using a single term, it is necessary to make estimates in line with each regional attribute for each sub-area. According to the theory of urban additive functions developed by Ricardo (1817), Mills (1972), and others, the fact that rent values decline as one moves farther away from city centers must also be factored into the estimates. These urban additive functions have previously been empirically validated (e.g., Koramaz and Dokimeci 2012). Using data from the Housing and Land Survey can solve this problem without requiring the acquisition of new data; that is, these data makes it possible to distinguish between municipalities and zones and to divide prefectures into three or four smaller areas, creating scope for improvement in rent estimates.

Regional characteristics include neighborhood environments (housing environment factors). For example, Boyle and Kiel (2001) demonstrated that housing prices are affected by the surrounding environment (neighborhood variables such as air quality). Earlier studies have found that the omitted variable bias effect of housing environment factors on land prices is significant (e.g., Hill 2013; Shimizu et al. 2013). As such, a method for estimating imputed rent, taking into account these factors, is also required. The Housing and Land Survey data include zoning, distances to nearby facilities, floor–area ratios (FAR), etc. It is possible to incorporate these variables as housing environment factors and analyze them.

2.2.2 Housing quality issues

According to Arévalo and Ruiz-Castillo (2006), indicators of housing quality are important, but the current estimation method casts doubt on this. The question here is whether only the variables of structural attributes of individual houses and completion period classifications can be used to capture housing quality, or whether other variables can also be used to more accurately measure housing quality. In the current estimation, the possibility that completion period classification variables compensate for everything related to housing quality except housing structure cannot be dismissed.

It is necessary to examine which variables representing housing quality should be incorporated into estimates, subject to the limitations of the Housing and Land Survey data. Specifically, referring to Hill (2013), we focus on construction types, housing types, structure types, building age, and the gap between rental and owner-occupied housing.

Construction types must be controlled for when estimating imputed rent because building costs and housing attributes differ depending on the type of construction. However, the current estimates do not account for construction types. For example, in Tokyo, detached houses and apartments account for 62.4% (6,204,776 ㎡) and 34.2% (3,424,682 ㎡) of the total floor space (9,993,036 ㎡) of housing (Table 1), respectively. Therefore, a method of estimating imputed rent should at least distinguish between detached houses and apartments. It is important to develop an estimation method for detached houses, which account for the majority of imputed rent in Japan. In the Housing and Land Survey, housing is classified into four construction types: detached houses, rowhouses, apartments, and others. Thus, it is possible to develop an estimation method specifically for detached houses.

Housing types of detached houses are separated into dedicated housing and housing combined with businesses (combined-use housing), although both categories are treated in the same manner in current estimates. As shown in Table 1, combined-use housing accounts for only 3.8% of all housing. However, due to the characteristics of this type of housing, it is often located in high-rent areas; thus, the impact of this housing type on rent estimates is likely to be significant. The Housing and Land Survey data include dedicated and combined-use houses in each construction type. Therefore, it is possible to distinguish between dedicated and combined-use detached housing and to create an estimation method that incorporates these differences.

Table 1 Total floor space of houses in Tokyo

Housing types	Construction types	Structures					Total
		Wooden	Fireproofed	SRC	S	Others	Composition ratio
Dedicated housing	Detached house	1,130,958	4,168,841	303,421	311,105	11,967	5,926,292 59.3%
	Attached house	21,526	132,927	38,257	24,873	1,462	219,045 2.2%
	Apartment house	19,237	90,535	3,143,777	158,709	340	3,412,598 34.1%
	Others	3,117	3,808	38,068	14,328	365	59,686 0.6%
	Subtotal	1,174,838	4,396,111	3,523,523	509,015	14,134	9,617,621 96.2%
Combination-use housing	Detached house	48,812	132,640	65,526	57,697	1,197	305,872 3.1%
	Attached house	559	4,059	1,144	1,401	-	7,163 0.1%
	Apartment house	465	498	6,010	5,111	-	12,084 0.1%
	Others	4,988	13,562	20,502	11,217	27	50,296 0.5%
	Subtotal	54,824	150,759	93,182	75,426	1,224	375,415 3.8%
Total		1,229,662	4,546,870	3,616,705	584,441	15,358	9,993,036
Composition ratio		12.3%	45.5%	36.2%	5.8%	0.2%	100.0%

Note: SRC and S are abbreviations for steel-framed reinforced concrete and steel-framed, respectively.
Source: Individual data from MIC, "2013 Housing and Land Survey"

Structure types may be wooden structures, which include wooden-frame, fireproofed wooden-framed structures, and others, or non-wooden structures, which include steel-framed reinforced concrete (SRC) and steel-framed (S) structures. However, current estimates consider housing structure; the method is simple and consists of only two categories: wooden and non-wooden structures. The Construction Research Institute categorizes structures as reinforced concrete (RC), SRC, and S structures, and points out that the prices and trends differ for each.[2] There are five structural categories in the Housing and Land Survey, and it is possible to categorize detached houses into three types of structures: wooden, fireproofed wooden, and non-wooden.

Building age is used as a proxy variable for housing deterioration. Respondents of the Housing and Land Survey form select a completion period classification. Thus, building age cannot be obtained from the survey, but information on completion period classifications can be obtained. Based on the assumption that housing values do not fall at a linear rate but instead decline with age following a convex curve, this classification based on years of age—ranging from the year of housing completion to four years earlier, every three years from five to seven years earlier, every five years from eight to 20 years earlier, and every ten years thereafter, with the same classifications applied to houses 65 years or older. In current estimates, these completion period classifications, which have more ambiguity than real building ages, are used to measure not only the aging of houses but also housing quality. Because building practices respond to revisions to laws and regulations, such as the Building Standards Law, there is a high correlation between the age and quality of housing; thus, it is assumed that the age of the building indicates the quality of the house. However, unlike previous periods when housing quality improved due to revisions to the Building Standards Law and other factors, housing quality has not necessarily been correlated with building age in recent years. This makes completion period classifications a poor proxy variable for housing quality. Under the constraint of unknown real building ages, it is very important to substitute these completion period classifications with building ages and then use housing quality data drawn from the Housing and Land Survey to clearly distinguish between age-related deterioration and house quality and to clarify the relationships between these two factors and rent.

Sato (2013) defined the gap in quality between rental and owner-occupied housing and noted that current imputed rent estimates do not consider the effect of differences in quality between the two types of housing. Determining the imputed rent of owner-occupied housing based on the rental value of rental housing from the Housing and Land Survey data is difficult because quality adjustments must be made as housing is an asset. In other words, there is a quality difference between rental housing, which prioritizes income and expenditures, and owned properties, which focuses on quality construction, but this difference is unclear because there are no data linking difference in quality to differences in rent. In this study, we focus on differences in construction costs by structure[2] and assume that the quality of housing is represented in the housing structure.

3. Method of analysis and data

The method of analysis has two stages: first, to gauge the influence of the relationship between rent and the factors of regional characteristics and housing quality, we conducted an analysis using the hedonic model. Next, we used the results of this analysis to yield a new estimation of imputed rent. Below, we explain the model used in the analysis and the estimation method we employed to estimate imputed rents. We then describe the data terms of the Housing and Land Survey as well as the data processing.

3.1 Analysis model

In our analysis, we incorporate regional characteristic and housing quality factors in the hedonic model using the ordinary least squares method to estimate the parameters of each variable. We also applied an alternative approach to building structures. We used real values rather than completion period classifications for building ages and employed variables that can be used to judge housing quality

[2] Construction Cost Index by the Construction Research Institute (Accessed: October 22, 2020) https://www.esri.cao.go.jp/jp/sna/data/reference1/h23/kaisetsu.html.

beyond age-related deterioration (Model 1). Moreover, as a robustness check, an analysis was performed using the completion period classifications for building ages (Model 2). The equation used in the model is as follows:

$$lnY = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon \qquad (i = 1,2,3\ldots,n) \qquad (1)$$

Here, lnY denotes the explained variable, log-transformed rent per ㎡; β_0 and β_i represent the constant term and coefficient, respectively; and i denotes the number of explanatory variables. X is a vector of explanatory variable. In addition, to assess the robustness of the results to changes in the specification of the completion period classification, the building age variable is used in Model 1 and the completion period classification variable is used in Model 2.

3.2 Estimation method

This study focuses on issues related to regional characteristics and housing quality and attempts to estimate imputed rent with an alternative approach in line with the current estimation method. Specifically, the imputed rent is estimated by taking into consideration the area in which the house is located and the house's construction and structure types. We selected houses from four areas, two construction types, and three structure types.

According to MIC (2013c), the data used as the basis for the current estimates are the results of the 2013 Housing and Land Survey. The data were divided by survey district, multiplied by the product of the inverse of the extraction rate, summed, and further multiplied by a set ratio to match the population of the municipality as of October 1 of the relevant year. In this study, however, we estimated and compared the results within that range based on the data used in the analysis. Therefore, the estimated amount of this study is a reduced version that differs from the population ratio of analytical data only.

3.3 Data and processing methods

We use individual survey data for Tokyo from the 2013 Housing and Land Survey in our analysis. We separated the survey data into two types: data showing regional characteristics and data showing housing quality. These were confirmed using the questionnaire (survey form) from the 2013 Housing and Land Survey (MIC 2013a) and its glossary of terms (MIC 2013b).

The data on regional characteristics included distance from the city center (*Surrounding central*, *Suburban*, and *Exurban dummy*) and location (*Outside sewage treatment areas*, *FAR*, the *Road width* in front of the house, and *Distance from public transportation)*. Different types of housing quality variables—dating (*Building ages* or *Completion period classifications)*, structure (*Wooden* and *S/RC structure dummy*), housing type (*Store combination dummy*), and space (*Number of floors* and *Floor area*)—were used to indicate the quality of the individual housing factors. Table 2 shows these variables and their descriptive statistics. The concrete processing method for the data is as follows.

Table 2 Data and descriptive statistics

Variable name [Unit/Category]	Frequency	Min	Max	Average	Standard deviation
Housing rent［Yen］	3335	10,000	450,000	100,839	59,428
Surrounding central dummy［0:Not applicable, 1:Applicable area］	4302	0.000	1.000	0.327	0.469
Suburban dummy［0:Not applicable, 1:Applicable area］	4302	0.000	1.000	0.226	0.418
Exurban dummy［0:Not applicable, 1:Applicable area］	4302	0.000	1.000	0.165	0.371
Outside sewerage treatment area［0:Inside treatment area, 1:Outside treatment area］	4302	0.000	1.000	0.071	0.257
FAR［%］ [FAR=Gross floor area/Area of the plot]	4293	50.000	700.000	213.564	114.471
Road width［1:Less than 2m, 2:4m, 3:6m, 4:10m, 5:10m or more］	4147	1.000	5.000	2.579	0.909
Distance from transportation［**Less than**: 1:200m, 2:500m, 3:1km, **Less than 2km from the station and from the bus stop:** 4:Less than 100m, 5:200m, 6:500m, 7:500m or more, **2km or more from station and from the bus stop:** 8:Less than 100m, 9:200m, 10:500m, 11:1km, 12:1km or more from the bus stop］	4302	1.000	12.000	3.834	2.394
Building age［Year］	3190	0.000	67.500	30.841	17.629
Completion period classification［**Less than:** 1:1 year, 2:2 years, 3:3 years, 4:4 years, 5:5 years, 6:8 years, 7:13 years, 8:18 years, 9:23 years, 10:33 years, 11:43 years, 12:43 years, 13:53 years, 14:54 years or more］	3190	1.000	14.000	9.793	2.670
Wooden dummy［0:Not wooden,1:Wooden］	4294	0.000	1.000	0.347	0.476
S/RC structure dummy［0:Not S/RC structure, 1:S/RC structure］	4294	0.000	1.000	0.078	0.268
Store combination dummy［0:dedicated housing, 1:Combined-use housing］	4302	0.000	1.000	0.060	0.238
Number of floors［Story］	4302	1.000	4.000	1.905	0.500
Floor space［㎡］	4302	5.000	1,000	80.245	48.289

As the distance from the city center cannot be understood in terms of the real values from the data of the Housing and Land Survey, we divide the regions into smaller areas using municipal codes to capture differences among four areas: central (12 wards), surrounding central (11 wards), suburban (17 cities, including Tachikawa), and exurban (three towns and a village, excluding islands, and nine cities including Hachioji) areas (Figure 1). With the central area as the reference point, we use three dummy variables (surrounding central, suburban, and exurban dummy) in our models. The dummy variables take a value of 1 for the corresponding areas when the data are applicable to the area.

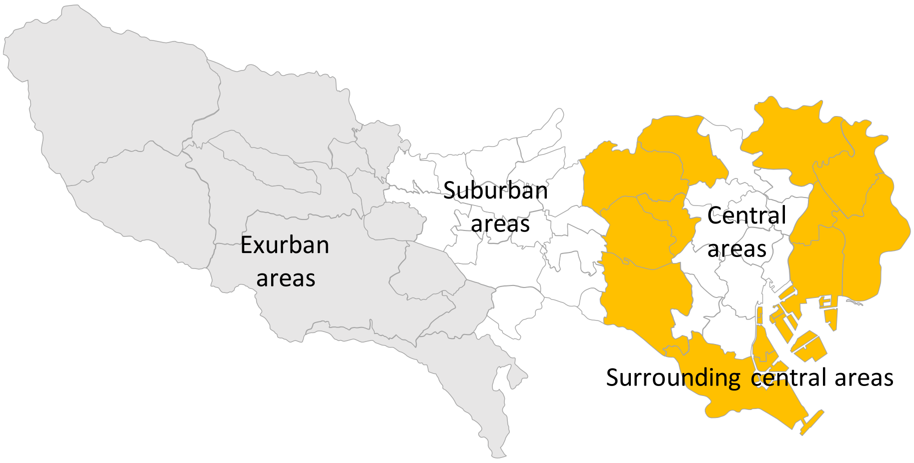

Figure 1 The four main areas in Tokyo

Next, we use a dummy variable to identify whether an area lies outside any sewage treatment areas. We use real data on FAR from the Housing and Land Survey. Similarly, we develop an ordinal scale for front-of-house road width using data from the same survey and use the existing categories in the survey to establish ordinal scales for distance from public transport, including the walking distance to a rail station or bus stop.

We use building ages and completion period classification as variables and verified the validity of housing age between the two variables. The building age variable is made from the median values of the periods comprising the completion period classifications.

Regarding housing structure, wooden and S/RC structure dummy variables are created and compared with the fireproofed wood structure variable, which is the benchmark. We use a dummy variable based on data from the survey to distinguish between combination-use and dedicated housing. For the number of floors and the floor space, we conduct a logarithmic transformation using the numerical data of the Housing and Land Survey and analyzed its results.

4. Results of the analysis and estimation errors

In this section, we review the results of the analysis and the new estimation of imputed rents. Based on these results, we discuss how to develop an alternate estimation method.

4.1 Results of analysis

Table 3 shows the results of our analysis. The degrees of freedom adjusted coefficient of determination of Model 1 is 0.350, whereas the variance inflation factor (VIF) for each variable is less than 10, indicating that multicollinearity is not an issue in our estimations. Excluding missing values, the sample size was 2,332. Although this analysis used the limited data provided by the Housing and Land Survey, the degrees-of-freedom–adjusted coefficient of determination would be expected to increase if, for example, distances from the city center are accurately measured by the variables. However, to improve the estimation method in line with the current estimation method, we focus here on the results in Table 3 rather than the missing variables. As the same variables are statistically significant in both Models 1 and 2, we hereafter focus on the results of Model 1.

The regional characteristic that positively affected rent is a wide road adjacent to the premises;

meanwhile, regarding factors specific to individual houses, rent is positively affected when the house had an S/RC structure, was combination-use housing, and had a greater number of floors. In particular, the coefficients for S/RC structure, combination-use housing, and number of floors are statistically significant at the 1% level in Model 2 as well as 1.

Conversely, the factors exerting a negative impact include regional characteristics, such as being located in a surrounding central, suburban, or exurban area; outside sewerage treatment areas; at a large distance from public transportation; or FAR. Factors specific to individual houses that have a negative impact included a wooden structure, an old building age, and a large floor space. All these coefficients are statistically significant at the 1% level.

From the above results, differences between regional characteristics over the three smaller areas are evident, and housing rent is lower in suburban areas. Furthermore, land attributes, such as FAR, distance from public transport, location outside a public sewerage treatment area, and the width of roads adjacent to the plot also affected rents. Proximity to public transport increases rent; in contrast, being located outside urban areas lowers rents. The results indicate that some kind of adjustment to account for these smaller areas is required in the current estimate. Furthermore, the FAR has a negative effect at the 1% significance level. This result suggests that consumers' assessments of their living environments are reflected, to some extent, in rents because of the greater comfort of residential-use districts compared with higher FAR areas, such as commercial-use districts. These variables related to urban planning should also be taken into account, as the current estimate does not consider sub-areas, districts, and the like.

Although older construction dates reduce rents, they do not encompass all aspects of housing quality among the statistically significant housing variables. Indeed, the coefficient for the building age or completion period classification variable is smaller than expected, as shown in Table 3, which suggests that using this variable as the only proxy for housing quality is inadvisable. However, they are statistically significant at the 1% level. These findings are evidence that housing age is an important and indispensable variable.

The fact that the wooden and the S/RC structure dummy are statistically significant indicates that differences in rents by structure, among fireproof wooden, wooden, and S/RC structures, are large for detached houses. This confirms that the estimation should consider more detailed classifications than the current building structure classification on detached houses. Moreover, increased floor space decreases rents due to diminishing marginal utility. Additionally, we confirm that dating is not the only statistically significant housing quality variable that impacts rents.

Table 3 Analysis results

	Model 1					Model 2				
	Coefficient		Standard error	t	VIF	Coefficient		Standard error	t	VIF
Surrounding central dummy	-0.094	***	0.033	-2.871	2.051	-0.089	***	0.033	-2.699	2.049
Suburban dummy	-0.197	***	0.037	-5.350	2.452	-0.189	***	0.037	-5.130	2.448
Exurban dummy	-0.379	***	0.041	-9.146	2.652	-0.365	***	0.042	-8.784	2.644
Distance from transportation	-0.014	***	0.005	-2.823	1.270	-0.013	***	0.005	-2.637	1.269
Outside sewerage treatment area	-0.191	***	0.047	-4.029	1.283	-0.194	***	0.048	-4.077	1.283
FAR	-0.001	***	0.000	-5.765	1.541	-0.001	***	0.000	-6.072	1.535
Road width	0.032	***	0.012	2.642	1.070	0.030	**	0.012	2.521	1.070
Building ages	-0.008	***	0.001	-11.545	1.184	-		-	-	-
Completion period classification	-		-	-	-	-0.045	***	0.004	-10.622	1.131
Wooden dummy	-0.043	***	0.026	-1.654	1.340	-0.049	*	0.026	-1.866	1.337
S/RC structure dummy	0.108	***	0.042	2.587	1.084	0.108	***	0.042	2.587	1.084
Store combination dummy	0.144	***	0.047	3.088	1.088	0.138	***	0.047	2.952	1.087
Number of floors	0.143	***	0.045	3.181	1.612	0.172	***	0.045	3.842	1.590
Floor space	-0.669	***	0.021	-31.214	1.183	-0.664	***	0.022	-30.889	1.180
Constant term	10.442	***	0.107	97.899		10.612	***	0.114	92.715	
Adjusted coefficient of determination			0.350					0.345		

Note: 1) n=2,332

2) Superscripts ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.2 Confirmation of differences in estimates

As the results of our analysis demonstrate that older building ages has a negative impact on rents, the validity of using completion period classifications in the current estimates is confirmed. We also find that factors specific to individual houses must be taken into account. Therefore, in subsequent imputed rent estimates, we included the building age or completion period classification and focused on the regional characteristics and quality of housing by type and structure, comparing these estimates with the current imputed rent estimates.

Table 4 shows the imputed rents calculated with the current estimation method. These rents are estimated by multiplying the gross floor space for each structure and completion period classification by the average rent per square meter. This total imputed rent is compared with our estimated imputed rent value (Table 5 and 6), calculated using the theoretical value of the hedonic model's coefficient to identify any differences.

Table 4 Current estimate

Structure	Completion period classification	Total floor space	Average ㎡ unit rent	Imputed rent
Wooden +Fireproofed	1	70,217	1,732.7274	121,666,917
	2	116,584	2,045.6535	238,490,467
	3	114,592	1,843.8928	211,295,365
	4	108,793	1,703.9406	185,376,812
	5	101,967	1,900.6880	193,807,449
	6	384,254	1,602.7184	615,850,948
	7	662,549	1,828.7304	1,211,623,474
	8	636,394	1,473.5258	937,742,956
	9	517,632	1,659.8737	859,203,734
	10	962,702	1,569.3250	1,510,792,297
	11	838,807	1,471.7466	1,234,511,386
	12	404,868	1,550.0452	627,563,720
	13	135,305	1,360.4764	184,079,253
	14	418,581	1,414.2116	591,962,098
S/RC	1	11,152	2,052.0369	22,884,316
	2	12,900	1,865.9862	24,071,222
	3	14,171	1,453.7037	20,600,435
	4	19,531	2,089.9809	40,819,417
	5	15,841	2,866.9057	45,414,654
	6	48,188	1,889.9839	91,074,546
	7	92,395	2,074.4861	191,672,142
	8	105,727	1,785.2118	188,745,088
	9	79,696	2,004.8768	159,780,664
	10	148,774	1,650.0797	245,488,964
	11	86,589	1,523.6278	131,929,405
	12	38,166	1,781.0470	67,975,439
	13	13,981	2,020.2020	28,244,444
	14	44,420	1,967.9455	87,416,141
Total		6,204,776	-	10,070,083,751

Note: The reason for the differences in total floor space between Table 1 and this table is a loss of data due to detail division.

In addition to detailing housing structure, we estimate imputed rents by taking into account individual housing factors, such as combined use housing and dedicated housing, building age, and sub-areas, as shown in Table 5. This results in an imputed rent of ¥10,459,526,292 (approximately 100 million USD based on 100 JPY per USD). Comparing this value with the imputed rents shown in Table 4, we find that the current estimates underestimate rent by 3.84% (¥386,442,540). This is assumed to be due to the high ratio of gross floor space in the 23 wards (central and surrounding central areas), which have the highest rent per square meter and indicate underestimation when the Tokyo prefectural area average is used.

This result shows that it is possible to conduct an estimate using the theoretical value of the coefficient of the hedonic model. Moreover, we can verify that regional characteristics and housing quality can be put into an estimation of imputed rent. This confirms the importance of dividing estimates into sub-areas, detail structures, and housing types.

Table 5 Estimate results of Model 1

Area	Housing type	Structure	Total floor space	Average ㎡ unit rent	Imputed rent
Central	Dedicated housing	Wooden	174,115	1,725.5818	300,449,675
		Fireproofed	493,737	1,751.4468	864,754,104
		S/RC	204,186	1,766.2560	360,644,747
	Combination-use housing	Wooden	14,005	1,740.6901	24,378,365
		Fireproofed	32,954	1,766.7816	58,222,520
		S/RC	45,842	1,781.7204	81,677,627
Surrounding	Dedicated housing	Wooden	346,303	1,673.3890	579,499,637
		Fireproofed	1,252,569	1,698.4717	2,127,453,028
		S/RC	239,697	1,712.8330	410,560,923
	Combination-use housing	Wooden	17,145	1,688.0403	28,941,451
		Fireproofed	46,797	1,713.3426	80,179,296
		S/RC	52,081	1,727.8296	89,987,095
Suburban	Dedicated housing	Wooden	342,476	1,650.4173	565,228,316
		Fireproofed	1,376,882	1,675.1557	2,306,491,703
		S/RC	116,294	1,689.3198	196,457,754
	Combination-use housing	Wooden	8,361	1,689.8225	14,128,606
		Fireproofed	30,672	1,704.1106	52,268,479
		S/RC	15,829	1,634.9723	25,879,977
Exurban	Dedicated housing	Wooden	263,863	1,620.7816	427,664,298
		Fireproofed	1,043,373	1,645.0758	1,716,427,647
		S/RC	49,614	1,658.9855	82,308,908
	Combination-use housing	Wooden	8,921	1,634.9723	14,585,588
		Fireproofed	21,072	1,659.4792	34,968,545
		S/RC	7,988	1,673.5107	13,368,004
Total			6,204,776	-	10,456,526,292

Using the coefficients of Model 2 and theoretical values based on completion period classification, we estimate our imputed rents by taking individual housing factors into account.

Table 6 shows the estimate results and an imputed rent of ¥10,049,749,034, which is 0.2 % less than the current estimates. There is a difference of 3.86% from the estimation results using the building age data. This implies that estimation results vary depending on how building age data are handled, and completion period classification is applied, even when estimation is done by house type or structure.

Table 6 Estimate results of Model 2

Area	Housing type	Structure	Total floor space	Average ㎡ unit rent	Imputed rent
Central	Dedicated housing	Wooden	174,115	1,693.5163	294,866,588
		Fireproofed	493,737	1,722.2679	850,347,380
		S/RC	204,186	1,736.8958	354,649,797
	Combination -use housing	Wooden	14,005	1,707.7445	23,916,962
		Fireproofed	32,954	1,736.7377	57,232,454
		S/RC	45,842	1,751.4885	80,291,734
Surrounding	Dedicated housing	Wooden	346,303	1,645.1496	569,720,235
		Fireproofed	1,252,569	1,673.0800	2,095,648,191
		S/RC	239,697	1,687.2901	404,438,384
	Combination -use housing	Wooden	17,145	1,658.9715	28,443,066
		Fireproofed	46,797	1,687.1366	78,952,931
		S/RC	52,081	1,701.4661	88,614,055
Suburban	Dedicated housing	Wooden	342,476	1,576.1391	539,789,823
		Fireproofed	1,376,882	1,602.8980	2,207,001,350
		S/RC	116,294	1,616.5120	187,990,644
	Combination -use housing	Wooden	8,361	1,589.3812	13,288,816
		Fireproofed	30,672	1,616.3649	49,577,144
		S/RC	15,829	1,630.0933	25,802,746
Exurban	Dedicated housing	Wooden	263,863	1,483.8298	391,527,770
		Fireproofed	1,043,373	1,509.0214	1,574,472,197
		S/RC	49,614	1,521.8381	75,504,475
	Combination -use housing	Wooden	8,921	1,496.2963	13,348,459
		Fireproofed	21,072	1,521.6996	32,065,254
		S/RC	7,988	1,534.6240	12,258,576
Total			6,204,776	-	10,049,749,034

The results of current estimation and Tables 5 and 6, respectively, show a positive and a negative relationship. We see a difference in the coefficients between the two analyses. Specifically, the coefficients of the age variable in Models 1 and 2. As pointed out by Karato et al. (2015), the relationship between age and price of houses is non-linear; we simply choose an optimum estimation.

The estimate results in Table 6 are already discussed in previous study (Fujisawa et al. 2021), therefore, we selected Model 1, and the following discussion is based on the results of Table 5.

4.3 Discussion

Two issues need to be addressed regarding the imputed rent estimates made (Table 5) in this study. The first is the validity of the analytical model, and the second is the validity of the estimation method.

4.3.1 Discussion of the analytical model

Concerning the analytical model, the degrees-of-freedom-adjusted coefficient of determination is 0.350; thus, we cannot exclude the possibility of omitted variable bias. For example, Fujisawa et al. (2021) pointed out that important variables, such as the distance from the city center and location in the central business district rather than the nexus of the sub-areas, may be necessary. As the Housing and Land Survey does not include this information, this is a limitation that also applies to the current estimates. However, the estimates in this survey, which employ sub-area classifications, also present a direction for improvement over the current estimation method. This can be regarded as Ricardian land rent, as proposed by Ricardo (1817), and this can be also confirmed from simple tabulations of the Housing and Land Survey that show that rents decline with distance from the city center.

The application of hedonic analysis enables the understanding of the actual rent conditions. The results suggest that estimation methods should include more detailed variables for factors specific to regional characteristics and individual houses. The findings also show that building age is a critical variable. If the method of evaluation is cost-based, the concept of depreciation rate for building deterioration could be included (Bokhari and Geltner 2018; Diewert et al. 2015), but this method is not applicable for Japan SNA, which estimates imputed rent from rent prices in the market. Our results indicate that imputed rent estimates need the building age variable not completion period classification.

Next, the results also show that the building age classifications are not an appropriate proxy variable for housing quality and confirm the need to incorporate factors specific to individual houses. The proposed method of analysis provides a minimal response to the arguments of Sato (2013); nevertheless, the hedonic model needs to be redeveloped. Changing the estimation method every five years by adapting the hedonic model to a base year also warrants consideration. This study was conducted using the limited Housing and Land Survey data, and it is necessary to examine the variables related to individual housing factors that should be used in the model in more detail.

4.3.2 Discussion of the estimation method

Our results confirm the need to consider regional characteristics, housing type, and structure when estimating imputed rent.

Regional characteristics require accurate estimation when a system of small areas are introduced in our estimate. As shown in Table 5, the total floor space within the 23 wards is overwhelmingly large, and it is reasonable to conclude that the current estimates do not capture the full extent of the real rent by multiplying simple averages by total floor space. In the future, the introduction of a weighted average method based each structure should be considered.

Housing type is used in the estimation method to adjust for housing quality, and the results confirm it as a significant variable. Thus, subject to data availability, estimates should at least be created using housing type and construction type as proxy variables for housing quality. In the current estimates, for example, average rent per meter square is obtained excluding combined-use houses and then multiplied by total floor space, which is totaled for both combined-use and dedicated housing. The results show that excluding combined-use housing leads to the underestimation of rents; thus, it is necessary to account for combined-use housing while creating estimates. In such a case, discussions on incorporating the quality of housing and living environments, based on the results of Hill (2013), are required. Hill and Syed (2016) confirmed that the difference between owner-occupied and rented houses was 18%; the result of our estimation in Table 5 is only 3.84% higher than the estimate produced by the current, less effective method. One reason could be that the new estimation was subject to data constraints. It is therefore suggested that the quality of housing should be adjusted using a more comprehensive method rather than at a micro level that only considers detached houses. In the future, a more comprehensive hedonic analysis and comparison of the estimation results are required.

We primarily use the structures-based approach in our estimation. As many previous studies (e.g., Hill 2013; Diewert and Shimizu 2016) pointed out, conducting estimates based on structure is important because it reflects the quality of housing. Our approach has highlighted the possibility of more accurate estimates than the current methods; future estimates can include weighted averages based on each structure, at least.

5. Conclusions

The SNA2008 calls for a more accurate estimation method for imputed rents, which are a non-market good, that reflects the circumstances of each country. Concerning estimating the imputed rent, this study followed the current “Explanatory Notes on the Methodology for Calculating the Statement of National Accounts” and examined whether data from the Housing and Land Survey, which is also used in current estimates, could reflect regional characteristics and housing quality. Especially, we tried to estimate imputed rent of detached houses with strong individuality.

In this study, we clarified the influence of regional characteristics and factors specific to individual houses on detached houses using a hedonic model analysis to propose an alternate estimation method. Theorical values from the obtained coefficients were used to estimate imputed rents that reflect regional characteristics and housing quality, and these values were compared to current imputed rent estimates. Our results indicate that imputed rent estimates need include the building age variable, but not completion period classification. As for the novelty of the study, it is shown that hedonic model analysis on detached houses is possible using Housing and Land Survey data, as higher estimation results than the current estimation were obtained. The alternative estimation method presented herein is an improvement on the current method and represents a realistic proposal for implementation.

The estimates in this study are created in a simplified manner based on our analysis. Although we highlight the differences between our estimates and those obtained using current methods, regional characteristics and housing quality adjustments, including age variables resulting from different estimates of building age and completion period classification, should be investigated more broadly. An ongoing discussion on investigations into new methods of estimation is required.

To consider a more rigorous estimation method, there is scope for future consideration of estimates that adapt the hedonic model. This has the additional advantage of being able to supplement data deficiencies in the model in regions where data collection is difficult. Going forward, the method by which statistical surveys are conducted should be reviewed. The adoption of a better and more rigorous hedonic model, including improvements to the current questionnaire, requires thorough consideration and careful research and discussion. These issues are to be addressed in the future.

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