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# Refining Real Consumption: Accounting for In-Kind Transfers, Imputed Rents, and Preference Heterogeneities

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**Abstract**

Over the past decade, expanded government in-kind transfers such as healthcare and education have influenced household welfare in many countries. To capture their effects on consumption inequalities, this study introduces an acquisition-based consumption measure that includes in-kind transfers and imputed rents, deflated using a superlative index. Using Japanese data from 2005 to 2021, we find that while conventional measures indicate an 11.2 percent decline in consumption among younger households, our index shows a 6.3 percent increase. Of the resulting 17.5 percentage-point gap, 10.7 points come from the deflator choice, while the rest arises from including in-kind transfers and imputed rents.

JEL Codes: C43, D12, D63, E01, E21.

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Understanding the extent and nature of economic inequalities between households, especially across different age groups, is important for maintaining social stability and informing effective economic policies. Although numerous measures of inequality have been proposed, household consumption is increasingly viewed as a more accurate indicator of economic well-being than either income or wealth (Attanasio and Pistaferri, 2016). This viewpoint has garnered increasing attention with the development of advanced microeconometric techniques and household consumption theories, prompting a growing body of research that examines the distribution of consumption across households (e.g., Heathcote et al., 2010; Coibion et al., 2021).

Despite these advances, the concept of "consumption" employed in most empirical analyses, as well as the methodologies used to measure it, have remained largely unchanged since the 1950s. Traditionally, household consumption is approximated by deflating total nominal expenditure—obtained from purchase records or self-reported survey data—by a consumer price index (CPI). While straightforward, this practice involves several significant limitations. The first concern is the mismatch between the theoretical definitions of consumption, which underlies its role as a utility determinant in economic models, and the expenditure data collected via purchase records or surveys. When the analysis is limited to information on household expenditures, it particularly overlooks the impact of consumption services provided through in-kind government transfers. For example, when government programs increase medical subsidies, household medical expenditures may decrease; however, this does not necessarily indicate a decline in the consumption of medical services. Such discrepancies become even more significant when in-kind government benefits like free medical services or education undergo substantial changes.

Governments worldwide have recently expanded their in-kind transfers to address various social needs. For example, the United States expanded Medicaid during the 2010s, while Germany abolished tuition fees for undergraduate students at public universities in 2014. Similarly, England introduced free childcare services with up to 30 hours per week for 3- and 4-year-old children in 2017, thereby benefiting working parents. Other countries have implemented comparable measures. Canada followed in 2021 with nationwide agreements to expand childcare and reduce its costs. In Japan, recent initiatives include free medical care

for young children and the elimination of tuition fees for higher education.

Problematically, these policies, while impactful overall, do not benefit all households equally. Households with specific attributes, such as those with young children, often experience the most significant gains, emphasizing the importance of tailored policy analysis concerning household welfare and consumption.

A second concern is the choice of a price deflator. In many countries, the official CPI is calculated using a Laspeyres index, which tends to overstate the true cost of living. Theoretically, a cost-of-living index (COLI), derived from expenditure functions, would be more appropriate, with a consequence being that the Laspeyres index typically exceeds the COLI. Moreover, deflators need not be uniform across households. Substantial differences in expenditure patterns, especially between younger and older households, necessitate household-specific deflators for accuracy.

In recognizing some of these shortcomings, various national and international statistical frameworks have revised their approaches. For insrance, the System of National Accounts (SNA) has adopted chained Fisher indices—superlative indices that approximate the COLI—while the International Comparison Program (ICP) introduced the Gini, Eltetö, Köves, and Szulc (GEKS)–Fisher formula for cross-country comparisons (United Nations et al., 1993; World Bank, 2020). Furthermore, since the 1970s, the ICP and subsequent SNA revisions have embraced the concept of "actual consumption," incorporating not only market expenditures but also in-kind government transfers, such as free health care and education (Kravis et al., 1975). Unlike traditional measures, actual consumption reflects what households acquire rather than what they spend, potentially diverging significantly from expenditure-based measures. In Japan's SNA, for example, incorporating actual consumption shows stronger growth due to increased government-funded health-care services, thus offering a clearer indication of improvements in living standards (United Nations et al., 1993).

Another often overlooked factor is imputed rent. Analyses relying solely on survey-based expenditure typically exclude the value of housing services that homeowners consume implicitly. If homeownership rates vary systematically across age groups, omitting imputed rents can distort measures of real consumption inequality over time. Changes in housing tenure patterns are thus critical for understanding the evolution of real consumption and

properly interpreting inequality measures.

This paper presents a practical approach to addressing these issues using data from Japan, where in-kind government transfers have been increasing. By leveraging microdata on household expenditures, residential floor space, elementary-level official price indices, and national health-care expenditure data disaggregated by household attributes, we construct comprehensive measures of real consumption. Our proposed measure incorporates imputed rents, accounts for in-kind government transfers, and employs superlative indices tailored to household characteristics, thereby approximating the cost-of-living index more closely than standard CPIs.

Our results reveal a stark difference between traditional measures and our welfare-based consumption index. Compared to a conventional measure indicating that real consumption declined by 0.118 logarithmic points (an 11.2% fall), our index increases by 0.061 logarithmic points (a 6.3% rise), creating a net gap of 0.179 logarithmic points (or 17.5%). Within this gap, 0.102 points (10.7%) derive from the choice of deflator and 0.077 points (8.0%) stem from the inclusion of in-kind transfers and imputed rents.

In conducting this analysis, this paper contributes to three important areas of the literature. The first is the cross-sectional analysis of household consumption, particularly concerning disparities in household consumption. As emphasized by Krueger et al. (2010) and Attanasio and Pistaferri (2016), heterogeneity among households is a key focus in modern macroeconomic models. Representative studies on consumption inequality include Blundell et al. (2008) and Heathcote et al. (2010). In Japan, notable contributions have been made by Lise et al. (2014), and more recently by Kitao and Yamada (2024), among others. Many of these studies calculate household consumption based on purchase information; for instance, if medical services are provided free of charge, medical consumption is recorded as zero. By considering government in-kind transfers and various subsidies in the analysis of household consumption, we believe this approach more accurately reflects the state of household welfare compared to standard household consumption data. Furthermore, our analysis demonstrates that incorporating these factors reveals significantly different patterns of consumption inequalties across household attributes.

The seconds concerns "inflation inequality," which recognizes that price changes differ

across households due to varying expenditure patterns (Muellbauer, 1974; Michael, 1979; Jaravel, 2018). Previous studies have often been limited in scope or data coverage, omit services and imputed rents, and have not systematically incorporated in-kind transfers. While some researchers have used city-level indices to apporoximate differences in living costs (Moretti, 2013) none, at least to our knowledge, have fully integrated in-kind government transfers with superlative index approaches.

The third pertains to estimating consumption by household attributes, as exemplified by the National Transfer Accounts (NTA) Project. While the NTA incorporates in-kind transfers and constructs individual-level consumption measures using administrative data, its primary focus is on the allocation of nominal expenditures. Discussion on the theory of aggregation or the selection of appropriate deflation methods remains limited. Consequently, the results produced by the NTA do not fully align with the theoretical framework of economic welfare.

By incorporating household-specific superlative indices and in-kind government transfers into the measurement of real consumption, this study bridges the gap between these two strands of literature. Therefore, it provides a more comprehensive view of household well-being that offers insights better aligned with economic theory and policy objectives.

The remainder of the paper is organized as follows. Section 1 illustrates the limitations of traditional real consumption measures. Section 2 introduces the data sources and the methodology for estimating imputed rents. Section 3 describes the procedures used to incorporate in-kind transfers into our welfare measures. Section 4 reports our empirical findings, and Section 5 discusses their broader implications for other areas of consumption research. Finally, Section 6 concludes.

# 1 Conventional Methods

## 1.1 Computing Real Consumption

The conventional welfare measure used extensively in consumption research is real consumption, calculated based on two key assumptions as follows: (1) household preferences are

homothetic, meaning the utility function can be represented by a homogeneous function of degree one in consumption quantities, and (2) the observed consumption bundle is consistent with utility maximization behavior.

Let $p_{it}$ and $q_{it}$ denote the price and quantity of commodity $i$ at time $t$, respectively, where $i = 1, \ldots, N$, and $N$ is constant over time. Under homothetic preferences, we have:

$$\sum_{i=1}^{N} p_{it} q_{it} = C\left(\mathbf{p}_t, u(\mathbf{q}_t)\right) \tag{1}$$

$$= u(\mathbf{q}_t) \times c(\mathbf{p}_t), \tag{2}$$

where $C(\mathbf{p}_t, u(\mathbf{q}_t))$ is the minimum cost function; $\mathbf{p}_t$ and $\mathbf{q}_t$ are price and quantity vectors, respectively; and $u(\mathbf{q}_t)$ is a utility function that is linearly homogeneous in quantities. The unit cost function $c(\mathbf{p}_t)$ represents the minimum expenditure required to achieve one unit of utility, i.e., $c(\mathbf{p}_t) = C(\mathbf{p}_t, 1)$.

Consider the change in household welfare from period 0 to period $t$, represented as $u(\mathbf{q}_t)/u(\mathbf{q}_0)$. Computing this directly requires specifying the utility function, which involves strong assumptions or complex estimation. Instead, a more convenient approach is typically employed.

Because the observed quantities and prices are assumed to be consistent with utility maximization, the following holds:

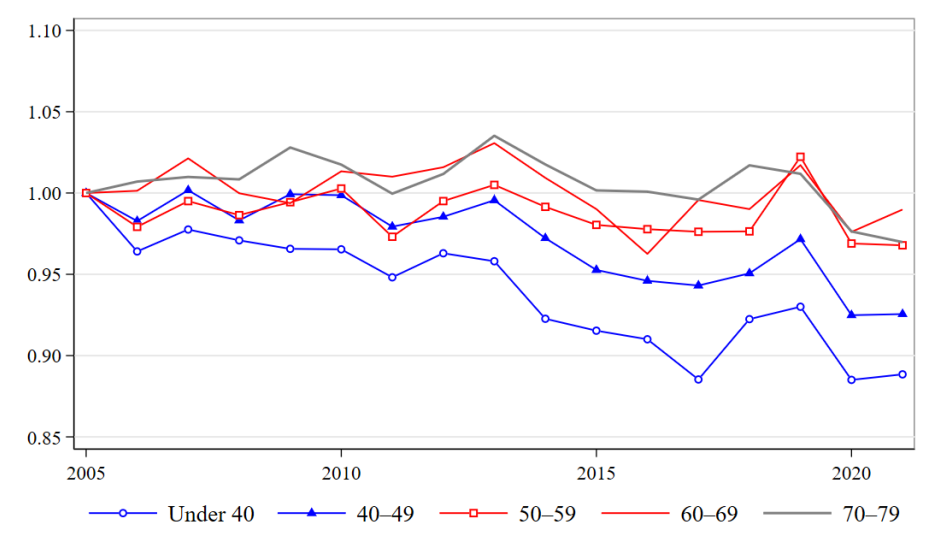
$$\frac{\sum_{i=1}^{N} p_{it} q_{it}}{\sum_{i=1}^{N} p_{i0} q_{i0}} = \frac{C(\mathbf{p}_t, u(\mathbf{q}_t))}{C(\mathbf{p}_0, u(\mathbf{q}_0))}. \tag{3}$$

Define the price index between periods 0 and $t$ as:

$$PI_{0t} = \frac{c(\mathbf{p}_t)}{c(\mathbf{p}_0)}. \tag{4}$$

This $PI_{0t}$ is the cost-of-living index (COLI), introduced by Konüs (1939). Dividing the

**Figure 1:** Real Equivalent Consumption Expenditures by Age Category (2005 = 1)




Note: Equivalent expenditures are calculated using the Organization for Economic Co-operation and Development's (OECD) modified equivalence scale.
Data source: (1) Price index: Ministry of Internal Affairs and Communications (MIAC), comprehensive CPI excluding imputed rent for owner-occupied houses using national figures.
(2) Nominal expenditures and household composition: Based on Family Income and Expenditure Survey (FIES), MIAC.

left-hand side of Equation (3) by the COLI in Equation (4), we have:

$$\frac{1}{PI_{0t}} \frac{\sum_{i=1}^{N} p_{it} q_{it}}{\sum_{i=1}^{N} p_{i0} q_{i0}} = \frac{c(\mathbf{p}_0)}{c(\mathbf{p}_t)} \frac{u(\mathbf{q}_t) c(\mathbf{p}_t)}{u(\mathbf{q}_0) c(\mathbf{p}_0)} \tag{5}$$

$$= \frac{u(\mathbf{q}_t)}{u(\mathbf{q}_0)}. \tag{6}$$

Thus, by dividing the ratio of total expenditures by the COLI, we obtain the ratio of utilities, which can serve as a measure of economic welfare. The main challenge is that the COLI's functional form is generally unknown. In practice, the official CPI is often used as a substitute for the COLI.

**Figure 1** plots equivalent expenditures for various age categories (in years), using the official CPI as the deflator.[1] As shown, the expenditures of younger households (under 40) exhibit a pronounced negative trend, whereas older households have more stable real

[1]We use the OECD's modified equivalence scale. Details for these data are provided in the next section.

consumption. This suggests widening economic inequality across age groups, with the gap increasing by about 10 percentage points over 15 years.

Accordingly, while the conventional approach is straightforward and easily implemented whenever household consumption data are readily available, it suffers from several serious shortcomings when used to compare welfare across individuals.

## 1.2 Discrepancy Between Purchases and Consumption

A key assumption in deriving household welfare from consumption expenditure is that households derive utility solely from purchased goods; however, households also benefit from goods and services that they do not directly pay for, such as in-kind government transfers (e.g., free or subsidized health care and education) and owner-occupied housing services (i.e., imputed rents).

Let $\mathbf{x}_t$ be a vector of unpurchased goods and services from which households derive utility. The utility function becomes $u(\mathbf{q}_t, \mathbf{x}_t)$. In this case, real consumption based solely on purchased goods no longer equals economic welfare:

$$\frac{1}{PI_{0t}} \frac{\sum_{i=1}^{N} p_{it} q_{it}}{\sum_{i=1}^{N} p_{i0} q_{i0}} \neq \frac{u(\mathbf{q}_t, \mathbf{x}_t)}{u(\mathbf{q}_0, \mathbf{x}_0)}. \tag{7}$$

If we assume that the utility function is multiplicatively separable between purchased and unpurchased items, we can write:

$$u(\mathbf{q}_t, \mathbf{x}_t) = U(\mathbf{q}_t) V(\mathbf{x}_t). \tag{8}$$

This yields:

$$\frac{u(\mathbf{q}_t, \mathbf{x}_t)}{u(\mathbf{q}_0, \mathbf{x}_0)} = \frac{U(\mathbf{q}_t)}{U(\mathbf{q}_0)} \cdot \frac{V(\mathbf{x}_t)}{V(\mathbf{x}_0)} = \frac{1}{PI_{0t}} \frac{\sum_{i=1}^{N} p_{it} q_{it}}{\sum_{i=1}^{N} p_{i0} q_{i0}} \cdot \frac{V(\mathbf{x}_t)}{V(\mathbf{x}_0)}. \tag{9}$$

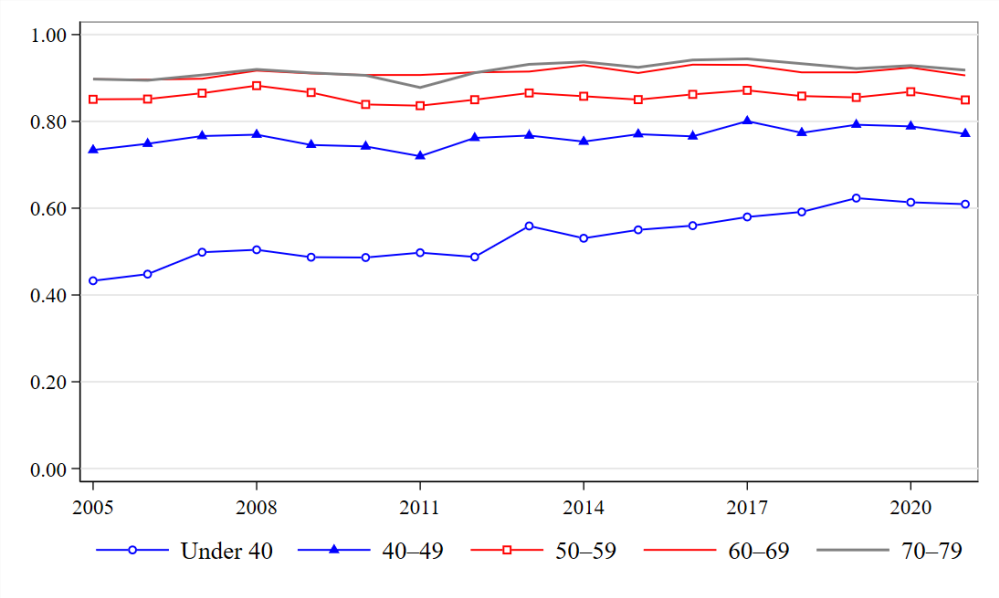
This decomposition will be used later to illustrate how conventional real consumption measures differ from welfare metrics that incorporate actual consumption.

### 1.2.1 Imputed Rents

A prime example of $\mathbf{x}_t$ is imputed rent. Households living in owner-occupied homes do not record rent payments; however, they consume housing services. In the SNA, imputed rents are included in household consumption expenditure, estimated using dwelling characteristics. Owner-occupied households are treated as receiving and simultaneously paying imputed rents as part of their income and expenditure.

Until the COVID-19 pandemic subsided, persistently low interest rates encouraged home purchases. **Figure 2** shows that the homeownership rate among households in their 30s in Japan rose from about 40% in 2005 to approximately 60% by 2021.[2]

**Figure 2:** Homeownership Rates by Age Category

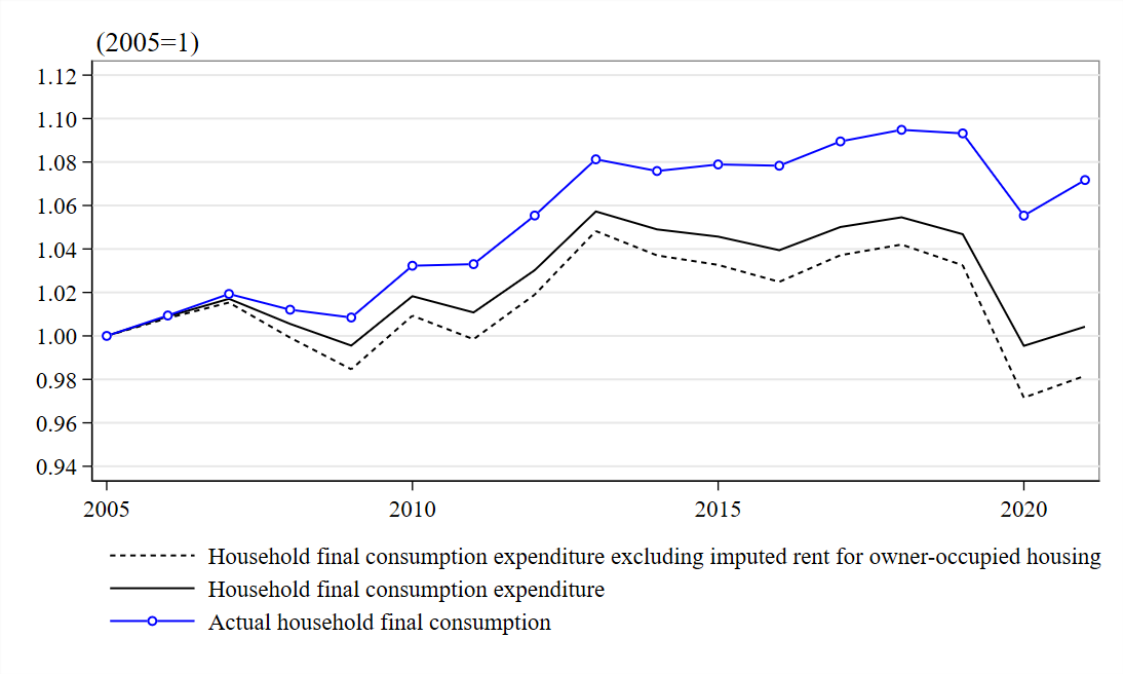



Data source: Family Income and Expenditure Survey, Ministry of Internal Affairs and Communications.

As shown in **Figure 2**, increases in imputed rent within a certain household group can affect observed consumption trends and consequently measured consumption inequality, depending on whether imputed rent is included.

[2]Details of these data are provided in the next section.

**Figure 3:** Real Household Final and Actual Consumption (2005 = 1)




Data source: "National Accounts," Cabinet Office, Government of Japan. Based on chained 2015 prices.

### 1.2.2 In-kind Transfers

Another significant component of $\mathbf{x}_t$ is in-kind transfers from the government, especially as their impact on household consumption has steadily grown in importance. **Figure 3** compares the trends in Japan's real *actual* household consumption with traditional real household final consumption expenditure, both calculated by the Cabinet Office, and normalized to 2005 = 1. Actual consumption, which includes in-kind government transfers, rose by about 10% over 15 years, while conventional measures stagnated, indicating that ignoring in-kind transfers may understate improvements in household welfare.

According to Japan's SNA, in-kind transfers amounted to 73 trillion yen (about 500 billion US dollars) in 2021, with over 60% allocated to medical services.[3] Thus, household consumption that includes imputed rents and in-kind government transfers, termed *actual consumption*, can diverge significantly from traditional household expenditure measures.[4]

[3]Social protection accounts for about 20% and education for around 16%.

[4]OECD (2024) outlines a method to aggregate in-kind transfers across household attributes, but there are few empirical estimations of real in-kind transfers and their distribution by household attributes.

## 1.3 Differences in Preferences Across Age Groups

A second concern in using traditional real consumption to measure inequality is the choice of deflator. The conventional method employs the official CPI, common to all households. However, the official CPI, being a Laspeyres index, may deviate from the COLI. Moreover, even if the COLI were used, differences in preferences between younger and older households would lead to distinct COLIs by age group.

The COLI for households with attribute $a$ is defined as:[5]

$$PI^a_{0t} = \frac{c^a(\mathbf{p}_t)}{c^a(\mathbf{p}_0)}, \tag{10}$$

where $c^a(\mathbf{p}_t)$ is the unit cost function for household type $a$. The real consumption for this household is:

$$\frac{1}{PI^a_{0t}} \frac{\sum_{i=1}^N p_{it} q^a_{it}}{\sum_{i=1}^N p_{i0} q^a_{i0}} = \frac{u^a(\mathbf{q}^a_t)}{u^a(\mathbf{q}^a_0)}. \tag{11}$$

If we use a common CPI instead of the household-specific COLI, we have:

$$\frac{1}{CPI} \frac{\sum_{i=1}^N p_{it} q^a_{it}}{\sum_{i=1}^N p_{i0} q^a_{i0}} = \frac{u^a(\mathbf{q}^a_t)}{u^a(\mathbf{q}^a_0)} \cdot \frac{1}{CPI} \frac{c^a(\mathbf{p}_t)}{c^a(\mathbf{p}_0)}. \tag{12}$$

The ratio of the CPI and the COLI drives the discrepancy between measured real consumption and actual welfare. Using a uniform national CPI can over- or underestimate household heterogeneity in consumption. While computing the COLI is not an easy task, Diewert (1976) showed that superlative indices (e.g., Fisher, Törnqvist, or Walsh indices) closely approximate the COLI. We adopt such superlative indices in this analysis.

Integrating the issues discussed above, if preferences are multiplicatively separable, we

[5] We assume identical prices across households. If this is not the case, prices would also carry the subscript $a$.

can write:

$$\underbrace{\frac{u(\mathbf{q}_t^a, \mathbf{x}_t^a)}{u(\mathbf{q}_0^a, \mathbf{x}_0^a)}}_{\text{Welfare Change}} = \underbrace{\frac{1}{CPI}\frac{\sum_{i=1}^N p_{it}q_{it}^a}{\sum_{i=1}^N p_{i0}q_{i0}^a}}_{\text{Conventional Real Consumption}} \times \underbrace{CPI\frac{c^a(\mathbf{p}_0)}{c^a(\mathbf{p}_t)}}_{\text{Cost-of-Living Adjustment Gap}} \times \underbrace{\frac{V(\mathbf{x}_t^a)}{V(\mathbf{x}_0^a)}}_{\text{Consumption Coverage Gap}} \tag{13}$$

In the empirical application in Section 4, assuming nonzero values for each component, we use:

$$\textit{Welfare Change} = \textit{Real Consumption} \times \textit{Price Difference} \times \textit{Coverage Difference} \times e_t, \tag{14}$$

where $e_t$ captures potential specification errors arising from data, estimation methods, and theoretical assumptions, such as approximations of the COLI by a superlative index, the multiplicative separability assumption, and measurement errors.

In summary, the conventional method for computing real consumption, while simple and widely used, may lead to substantial biases in welfare comparisons across different households, particularly when the scope of consumption and the price indices fail to capture household-specific preferences, in-kind transfers, and imputed rents.

# 2 Data and Computation of Attribute-Specific Actual Consumption

In this section, we describe the data and method used to calculate household welfare measures based on consumption, addressing the points raised previously. Specifically, we construct a consumption inequality indicator that incorporates (1) imputed rents, (2) in-kind transfers, and (3) heterogeneity in preferences.

## 2.1 Household Expenditure Weight: Family Income and Expenditure Survey by the Statistics Bureau of Japan

The Family Income and Expenditure Survey (FIES), produced by the Statistics Bureau of Japan, is a monthly survey of households based on household accounts of expenditures

on about 600 detailed consumption expenditure categories. The results are widely used to calculate weights for the official CPI, preliminary gross domestic product (GDP) figures, and are included in academic research, such as Lise et al. (2014). In this paper, we use the household-level data from the survey over the period January 2005 to December 2021 to obtain information on expenditures by household attribute. In other words, the monthly expenditure information by item for each household attribute is matched with the price information to be discussed, and an upper-level index is calculated, such as the Törnqvist index.[6]

In this study, we use information on household attributes, such as housing type, residential region, and the age of each household member, which enables the calculation of equivalent expenditure using the OECD-modified scale and facilitates data matching with datasets other than the FIES, as discussed later. We focus on households with two or more members and a household head aged under 80 years. **Table 1** presents the basic statistics. When pooling across all periods, we analyze 1,443,251 households in total. The average age of household heads was 54.0 and 57.4 years in 2005 and 2021, respectively. Although the number of household members exhibits a declining trend over time, there is no significant change in equivalent expenditure. As **Figure 2** shows, the homeownership rate in younger households has increased, which is also reflected in the rising homeownership rate shown in **Table 1**.

## 2.2 Prices: Consumer Price Index by the Statistics Bureau of Japan

In this study, we use the 2015-based CPI instead of the most recent 2020-based CPI. We do this because the analysis period of this study spans the period from 2005 to 2021, and using a base year closer to the midpoint of the analysis period allows for the inclusion of as many items as possible in the estimation of the price index. The 2015-based CPI

[6]We limit our analysis to households with two or more members because the number of surveyed single-person households in the FIES is small and the number of survey months is less than half that of multimember households. Furthermore, the Quarterly Estimates of the SNA also do not use information on single-person households, making data on households with two or more members the primary source for these key series. It should be noted that the Official CPI of Japan as employed in this study, also does not use expenditure data from single-person households.

**Table 1:** Basic Statistics for the FIES

| Year | N | Age of Household Head | Household Size (OECD Scale) | Equivalized Expenditure on FIES items (Unit: Yen/Month) | Homeownership Rate |
|---|---|---|---|---|---|
| 2005 | 89,931 | 54.0 | 1.99 | 135,939 | 0.771 |
| 2006 | 88,849 | 54.1 | 1.99 | 134,387 | 0.775 |
| 2007 | 88,450 | 54.6 | 1.98 | 136,598 | 0.797 |
| 2008 | 88,414 | 54.6 | 1.97 | 136,855 | 0.808 |
| 2009 | 88,234 | 54.7 | 1.96 | 135,702 | 0.795 |
| 2010 | 87,835 | 55.1 | 1.96 | 135,217 | 0.790 |
| 2011 | 85,448 | 55.3 | 1.96 | 132,496 | 0.783 |
| 2012 | 85,777 | 55.9 | 1.95 | 134,085 | 0.806 |
| 2013 | 85,667 | 56.1 | 1.95 | 136,187 | 0.828 |
| 2014 | 85,235 | 56.4 | 1.94 | 137,649 | 0.826 |
| 2015 | 84,575 | 56.8 | 1.94 | 137,020 | 0.827 |
| 2016 | 83,061 | 57.0 | 1.93 | 135,371 | 0.839 |
| 2017 | 82,683 | 57.3 | 1.93 | 136,621 | 0.852 |
| 2018 | 81,514 | 57.0 | 1.92 | 139,681 | 0.838 |
| 2019 | 79,926 | 56.9 | 1.92 | 143,335 | 0.842 |
| 2020 | 79,467 | 57.2 | 1.91 | 136,813 | 0.848 |
| 2021 | 78,185 | 57.4 | 1.91 | 137,587 | 0.836 |

Note: The figures in the table represent the weighted average calculated using aggregation multipliers, specifically for households with two or more members. For each month, households in the top and bottom 1% by expenditure are excluded.

comprises 585 expenditure items, of which 501 items, including the imputed rent for owner-occupied housing, are surveyed continuously from 2005 to 2021. In addition, excluding public kindergarten fees, which have been assigned a CPI value of 0 since October 2019, 500 items are used for calculating the price index. For elementary-level indices, national-level data are used as prefectural-level data are not publicly available. This price information is matched with expenditure data by household characteristics from the FIES. If there is no one-to-one correspondence between the CPI and FIES items, expenditure amounts are allocated proportionally within the higher-level intermediate classification category of the elementary index. Specifically, this proportional allocation is used in cases where items have been newly introduced or discontinued, or for items such as fresh vegetables and fruits that are only

available seasonally. In addition, as mentioned earlier, public kindergarten fees are excluded from the index calculation after their CPI value became zero. To address this problem, the price information for private kindergarten fees is matched with data on kindergarten fees regardless of whether they are public or private kindergartens.

## 2.3 Imputed Rent

Imputed rent, although not recorded in household account books or involving any actual monetary transactions, represents a significant economic value, which accounts for about 16% of household consumption expenditure in the SNA. Its calculation at the household level requires detailed information about the characteristics of owned homes, such as size, location, and age, as well as data on private rental markets. In the FIES, the content of questions regarding housing varies slightly depending on the survey period, but the most recent question items are as follows. For owner-occupied households, questions are set on the total floor area of the residence, the number of rooms, and the construction period. For nonowner-occupied households, questions are asked about rent and total floor area. When estimating the imputed rent for owner-occupied households, a rent function based on private market rents is estimated. The explanatory variables available for this estimation are limited to the total floor area of the residence and regional dummy variables. However, given our focus is not on estimating the imputed rent for individual households, rather deriving the average imputed rent for groups with specific household attributes, the influence of any unobserved variables is less critical. To ensure the validity of the imputed rent estimated, a comparison is made with the estimation values provided by the MIAC. Details of the estimation method, data used, and results are presented in Appendix 1, where it is confirmed that the independently estimated values and those provided by the Ministry do not differ significantly.

## 2.4 Index Number Formula

In the traditional calculation of real consumption, the official CPI based on the Laspeyres index is typically used as the deflator. In contrast, the SNA and ICP frequently employ

index number formulas based on the Fisher index. Using expenditure data covering the entire period from household surveys and price data for each item across different periods from price surveys, we can select from various candidate index number formulas to calculate the deflator.

**Figure 4** depicts the differences among the several price indices in Japan, including the imputed rents obtained by the methods previously described. Compared to the official CPI, the Paasche and Törnqvist indices present significant differences. Further, while the Fisher and Törnqvist indices are both superlative indices, the latter is more stable.[7] For this reason, we employ the Törnqvist index in the price index number formula.[8] By calculating the Törnqvist index across household attributes, we can assign an economic welfare dimension to the resulting real consumption, enabling a more accurate measurement of inequality between households. As discussed later, constructing a superlative index for each household attribute also plays a crucial role in accounting for the impact of in-kind transfers.

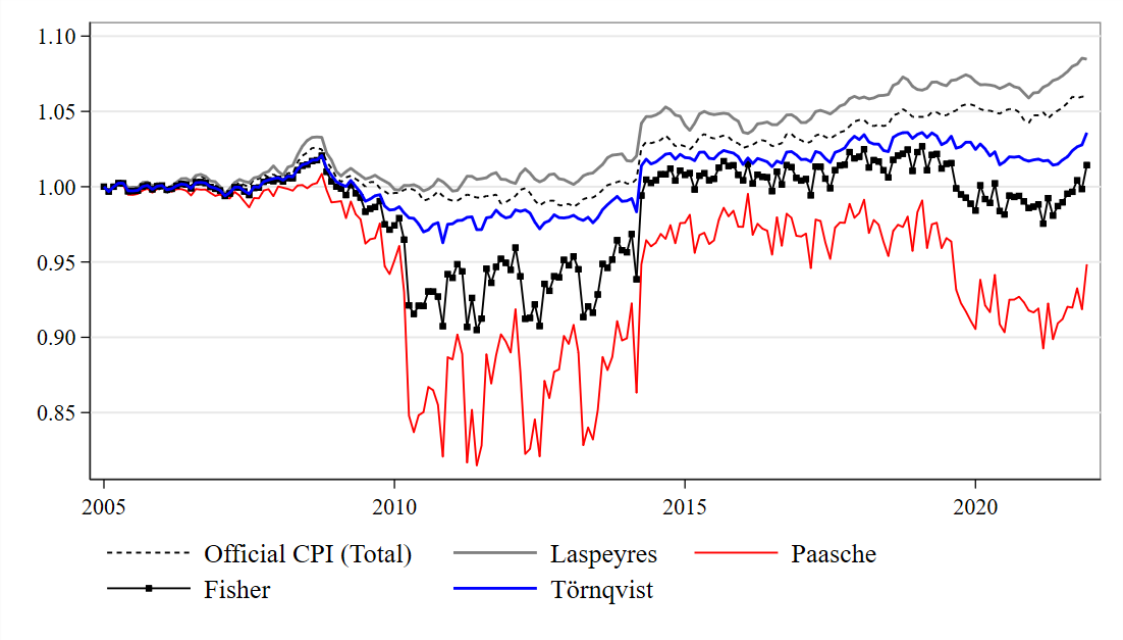
# 3 Estimation of the Effects of In-Kind Transfers

The services and goods provided by the government to households range from collective or public goods—such as public safety and diplomatic services—to commodities offered at no or low cost, such as elementary education and health care. In the context of consumption inequalities among households, as in the SNA, collective or public goods are excluded given the difficulty of measurement. Instead, we focus on private consumption goods provided or subsidized by the government, with a particular emphasis on health-care and medical services.

[7]There is a slight divergence between the Laspeyres index we calculated and the official CPI. Potential reasons are: 1) the official CPI is based on the 2020 reference period, whereas ours uses January 2005 as the reference period; and 2) the items in the Household Survey and those in the CPI do not correspond perfectly, and the allocation ratios used in the official CPI are not disclosed. As a result, we assumed equal allocation ratios when adjusting.

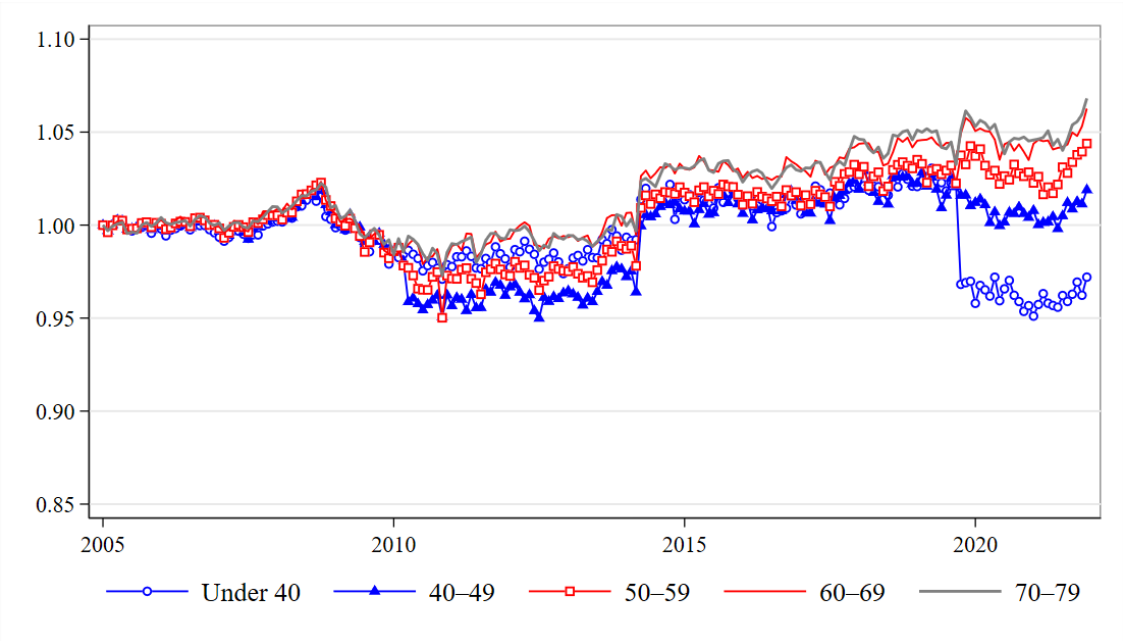
[8]It is important to note that both the Paasche and Fisher indices exhibit unstable behavior in Japan. This instability primarily arises because the harmonic mean of the price changes, used in the calculation of both indices, tends to produce extremely low values when even a single extremely small value is included, in contrast to the arithmetic mean used for the Laspeyres index or the geometric mean for the Törnqvist index. For example, in 2011, Japan significantly increased subsidies for high school tuition, leading to a substantial drop in the CPI for higher education. This change resulted in a pronounced decline in both the Paasche and Fisher indices.

**Figure 4:** Comparison of Price Indices




Note: Except for the Official CPI, the figures are our estimates based on information from the elementary-level CPI and the FIES. The items covered by our estimation include the items from the FIES and the imputed rent for owner-occupied houses estimated independently.

**Figure 5:** Törnqvist Index Considering Single Attribute: Age Category




Note: Includes imputed rent for owner-occupied houses estimated independently.

Estimating household-level actual consumption, as reflected in the SNA, often relies on directly quantifying the volume of government-provided services. However, this approach is considered impractical at the household level. Measuring changes in actual consumption by household attributes —i.e., real actual consumption—does not always necessitate such detailed, supply-side information at the individual level. Instead, in many cases, attribute-specific price indices can effectively capture these changes.

## 3.1 Case 1: When the Attribute-Specific Price Index Captures Actual Consumption

National official CPIs typically offer a single price index for detailed commodities. In Japan, for instance, indices are published for over 600 items. If government subsidies for a particular good increase—thus reducing household out-of-pocket costs—the official CPI should reflect a decline in prices proportional to the subsidy change. Under certain conditions, changes in subsidies and household burdens are captured by the official CPI.

The first condition is that government subsidies must not depend on household attributes. For example, if a health-care subsidy applies only to younger households, the official CPI would reflect the average impact of the subsidy across all households. In this case, the subsidy's impact on the targeted households cannot be fully assessed using the official CPI alone; additional data would be required.

The second condition is that prices must not be 0 throughout the sample period. If the price drops to 0 for all periods, households would consistently report 0 expenditures for that item, leading it to be excluded from coverage of the official CPI. Without recorded expenditure, no corresponding price index would then exist for that item.

In 2019, preschool and kindergarten fees for children aged three and older in Japan became free of charge. Prior to this policy change, childcare fees were determined by a complex formula that accounted for factors such as household income, the number of children, the employment status and working hours of each household member, the health status of family members, and the region of residence. Using this formula, monthly costs could be as high as 100,000 yen (approximately 660 US dollars) per child. Starting in October 2019,

preschool and kindergarten fees were eliminated for children aged three and over, irrespective of household characteristics, such as income or the age of the household head.[9] Consequently, the kindergarten fee index decreased from 97.7 in September 2019 to 4.9 in October 2019, and the nursery fee index fell from 97.5 to 40.9 over the same period.

For households without young children, this price decline is irrelevant. Moreover, because the 2015-based CPI assigns a 0.83% weight to kindergarten and daycare facilities, even a sharp price drop has little impact on overall prices and household welfare. In contrast, for households with young children—specifically, two-or-more-member households with a head under age 40—the weight before September 2019 was as high as 3.8%. For these households, the price decrease significantly affects their cost of living and economic welfare.

By using an age-specific CPI—or, more precisely, an age-specific Törnqvist index—we can capture this effect. The significant movement in the childcare service price index in October 2019, (see **Figure 5**) highlights the impact on younger households. Thus, an attribute-specific CPI allows us to recognize that partial subsidization of childcare services benefits households using these services, while having apparently little effect on others.

## 3.2 Case 2: When Supply-Side Information Is Necessary

If government-provided services vary by household attribute—offered at different prices or free only to certain age groups—then the official CPI, which assumes uniform pricing, cannot capture these changes. For example, if medical expenses were made free for children under age 15 while simultaneously increasing costs for the elderly, the official CPI, reflecting a population average, could not measure attribute-specific inequality. In such cases, we must rely on sources of information other than the CPI and household expenditure.

We focus on in-kind health-care services provided by the government. Using national medical statistics, we impute the medical services received by each household.

[9]The level of in-kind government benefits in childcare and preschool services prior to the introduction of free fees depended on household characteristics. Therefore, changes in in-kind government benefits also varied depending on these characteristics. However, for the purposes of this analysis, we assume that the policy was implemented uniformly across all households and that, prior to the policy change, households faced the national average price of childcare and preschool services. Relaxing this assumption would require detailed information on factors such as the working hours of individual household members, the health conditions of cohabiting family members, and more. At this stage, it was not feasible to undertake such an analysis.

## 3.3 Estimation of Actual Consumption of Medical Services

As explained, the level of subsidies—and therefore the prices of medical and health-care services—can vary substantially by age, including the possibility of a zero cost. This variation makes use of a single price index for health-care services inappropriate.

To estimate age-specific in-kind health-care and medical benefits, we use the National Medical Care Expenditure (NMCE) provided by the Ministry of Health, Labour and Welfare (MHLW) in Japan. This statistic estimates all insurance-covered expenses for treating illnesses and injuries at medical institutions during the year, encompassing medical and dental treatment fees, pharmacy dispensing costs, inpatient meals and accommodations, and home nursing care costs.[10]

The NMCE breaks down medical costs by age group, showing how much national resources are allocated annually per person by age.[11]

**Figure 6** plots the level of medical expenses for each age group, while **Figure 7** illustrates their trends, which are normalized to 1 in 2005. Although substantial resources are allocated to the elderly, expenditures on younger age groups in Japan have been rising rapidly in recent years. From 2005 to 2021, medical spending on the 10–14 age group increased by 1.57 times, whereas medical spending for those aged in their 70s remained almost unchanged. Such divergent trends can significantly influence real consumption and in-kind transfers across age groups.

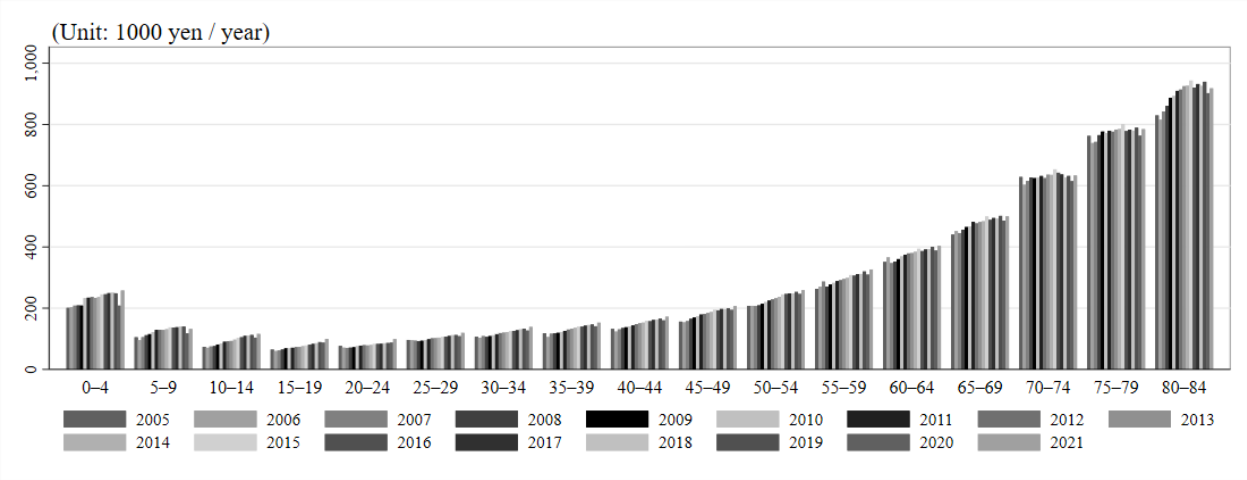
Medical expenses recorded in the FIES represent out-of-pocket expenditures, traditionally used to measure conventional real consumption. In this study, we exclude these out-of-pocket medical expenditures from $p_{it}q_{it}^a$ in Equation (13). Instead, we use the national medical expenditure as part of $\mathbf{x}_t^a$. Given the FIES reports each household member's exact age, the per capita medical expenditures by age from the NMCE can be assigned to every household member.[12]

[10] See `https://www.mhlw.go.jp/english/database/db-hss/dl/outline2017.pdf` for details.

[11] The NMCE does not include certain health-care and medical benefits. First, it excludes expenditures for high-cost medical services not covered by national health insurance. Second, expenditures associated with long-term health-care insurance are also omitted. Changes in these allocations could potentially affect actual consumption and welfare but cannot be examined here given the lack of publicly available data. We defer this subject to future research.

[12] As the National Medical Care Expenditure data are annual, we divide by 12 to obtain monthly amounts.

**Figure 6:** Nominal Health Care Expenditures by Age Category (Per Capita, Thousand Yen/Year)




Data Source: "National Medical Care Expenditure," Ministry of Health, Labour and Welfare (MHLW).

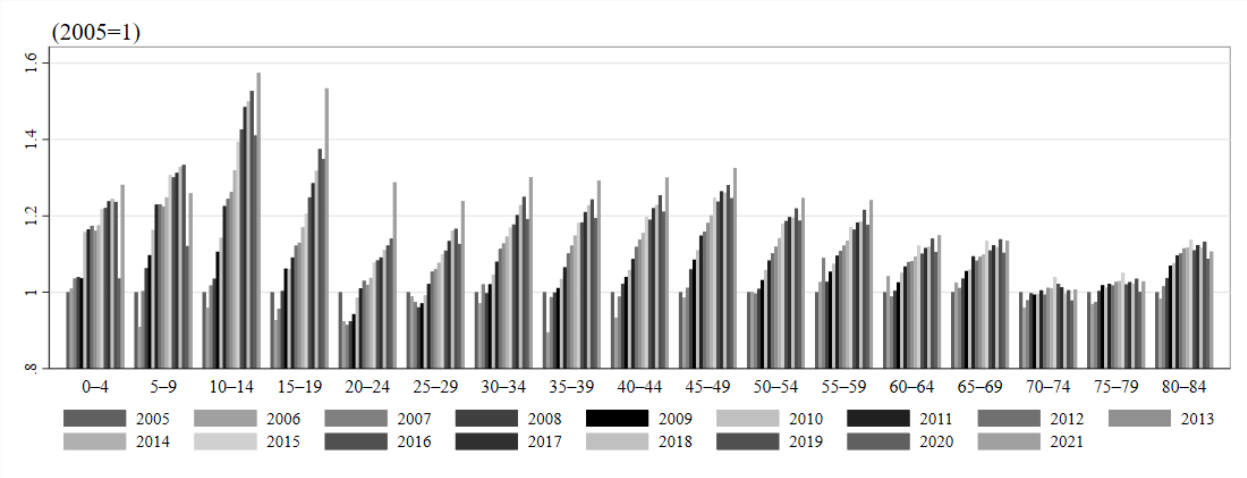
Please Note that the NHCE values are assigned even to those that did not visit medical institutions during the survey month.[13] However, given our focus is on real consumption by age category rather than on individual households, the use of age group averages is acceptable.

## 3.4 Constructing Attribute-Specific Aggregate Actual Consumption

We merge the imputed rent and national medical expenditures with each household record in the FIES. Using the corresponding official CPI for imputed rent and the SNA medical expenditure deflator as price indices, we construct a Törnqvist index by age and region with 2005 as the base year. Deflating the changes in nominal expenditure since 2005 by the Törnqvist index yields real household actual consumption.

[13]The FIES does not identify whether each household member visited a medical institution. Thus, if children have zero out-of-pocket medical expenses, it is recorded as zero, even if they received health care.

**Figure 7:** Nominal Health Care Index by Age Category (Per Capita, 2005 = 1)




Data Source: "National Medical Care Expenditure," Ministry of Health, Labour and Welfare (MHLW).

## 3.5 Alternative Method for Obtaining Actual Consumption

Although the Törnqvist index, as a superlative index, provides a good approximation of the true cost of living, incorporating external data—such as with the NMCE—it does raise some concerns. As pointed out by Cutler et al. (1998), government-provided medical services, offered free of charge, do not necessarily align with household expenditure-minimizing behavior. Even if using medical services reflects some degree of optimization, it is shaped by factors such as health conditions and time constraints, which deviate from the assumptions of standard cost-of-living theory.

To assess the robustness of our estimation results, we employ an alternative approach to quantify the impact of medical services on economic welfare. Specifically, we specify a Cobb–Douglas aggregator that combines medical expenses and other consumption, including imputed rents, to derive changes in economic welfare (expressed as a quantity index) using a Cobb–Douglas utility function.

More concretely, we construct a welfare indicator incorporating health and medical care as follows:

1. Aggregate the NMCE assigned to each household by age group.

2. Deflate the total medical expenditure for each age group using the SNA medical care

deflator, yielding a real measure of medical service consumption.

3. Compute the expenditure share of medical care (including government contributions) for each age group, $\alpha^a$, and specify it as a weight in a Cobb–Douglas utility function with two goods: medical and nonmedical care consumption:[14]

$$\frac{u(\mathbf{q}_t^a, \mathbf{x}_t^a)}{u(\mathbf{q}_0^a, \mathbf{x}_0^a)} = \left[\frac{1}{PI_{0t}^{a,J}} \cdot \frac{\sum_{i\in J} p_{it} q_{it}^a}{\sum_{i\in J} p_{i0} q_{i0}^a}\right]^{1-\alpha^a} \cdot \left[\frac{V(\mathbf{x}_t^a)}{V(\mathbf{x}_0^a)}\right]^{\alpha^a}, \tag{15}$$

where $J$ is the set of commodities from the FIES excluding health-care services and including imputed rents. The parameter $\alpha^a$ represents the expenditure share of medical care for age group $a$.[15]

# 4 Empirical Results

**Figure 8** presents the key findings of this analysis. The gray lines depict real consumption calculated using the conventional method, where nominal expenditures are deflated by the official CPI. The dotted lines plot real consumption measures that incorporate imputed rents, while retaining the conventional deflation method. **Figure 8** (Panel 1) clearly demonstrates that imputed rents majorly affect younger households, whereas their inclusion leads to negligible changes among elderly households. Additionally, altering the deflator from the official CPI to a common Törnqvist index, shared across all households, does not impact real consumption for any age group. However, replacing the common Törnqvist index with an age-specific Törnqvist index does have a pronounced effect on younger households. Finally, incorporating government-provided medical services influences all age groups, except the oldest.

**Figure 9** provides an alternative perspective on the results shown in **Figure 8**. Whereas **Figure 8** focuses on differences in estimation methods for each age group, **Figure 9** compares changes in real consumption across age groups under each deflation method. Panel

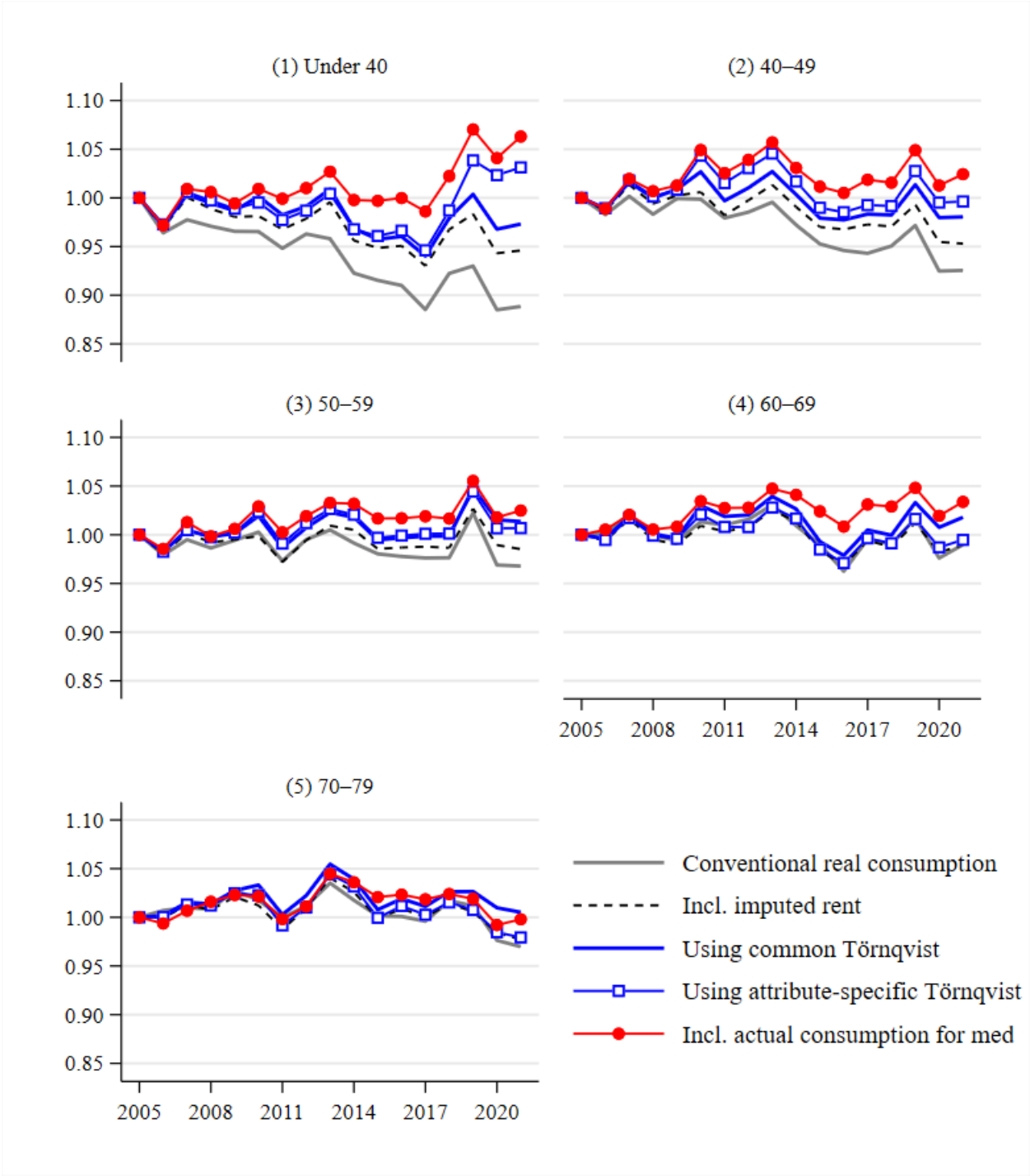
[14] In other words, we are assuming that the government provides a level of medical services that reflects household welfare by age category of the household head.

[15] To compute $\alpha^a$, let (1) be the expenditure amount on $J$ and (2) be the medical expenditures estimated from the NMCE. We calculate $(2)/((1)+(2))$ for each year and age group, and take the simple average over the analysis period. See Table 3 for the estimation results of $\alpha^a$.

1 in **Figure 9** is identical to **Figure 1** presented in Section 1. Under the traditional measure of real consumption—where household expenditures are deflated by the official CPI—substantial differences across age groups are evident. That is, younger households experience sharp declines in real consumption, while elderly households remain more stable.

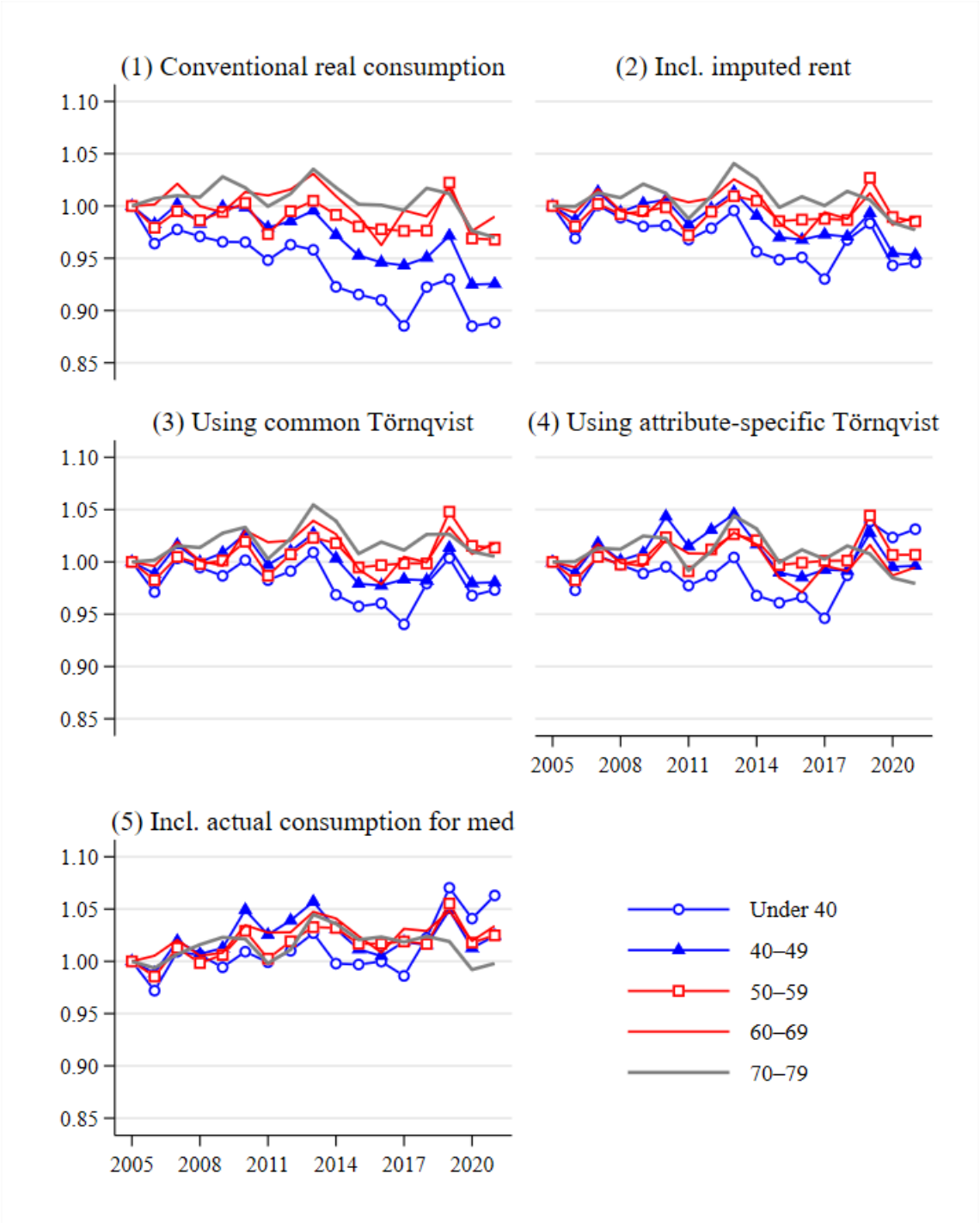
In contrast, our welfare measure (Panel 5 of **Figure 9**) incorporates age-specific Törnqvist indices, imputed rents, and in-kind government health-care and medical service transfers. This approach yields far smaller disparities across age groups, presenting a stark contrast to the traditional real consumption measure and offering a substantially different perspective on household economic welfare.

**Figure 8:** Real Consumption Trends: By Age Category × Aggregation Method




*Note:* For items not covered by the FIES, the following price information was used. While imputed rents for owner-occupied houses were independently estimated, the corresponding price data are based on elementary-level indices from the CPI. For medical services derived from the "National Medical Care Expenditure," the GDP deflator for "Health and Medical Care" was employed.

**Figure 9:** Real Consumption Trends: Aggregation Method × By Age Category




*Note:* See the notes for Figure 8.

**Table 2:** Decomposition of the Factors Contributing to Welfare Change

| | Under 40 | 40–49 | 50–59 | 60–69 | 70–79 |
|---|---|---|---|---|---|
| (1) Welfare Change | 1.0630 | 1.0244 | 1.0249 | 1.0338 | 0.9980 |
| (2) Conventional Real Consumption | 0.8885 | 0.9255 | 0.9678 | 0.9898 | 0.9698 |
| (3) Cost-of-Living Adjustment Gap | 1.1075 | 1.0537 | 1.0237 | 0.9989 | 0.9909 |
| (4) Consumption Coverage Gap | 1.0804 | 1.0504 | 1.0344 | 1.0456 | 1.0384 |

*Note:*

(1) Welfare Change refers to our welfare indicator, which includes imputed rent and in-kind government transfers for health and medical care, and is deflated using age-specific Törnqvist indices.

(2) Conventional Real Consumption is the traditional measure of real consumption, computed by deflating household expenditure with the official CPI.

(3) Cost-of-Living Adjustment Gap is the ratio of the official CPI to the age-specific Törnqvist indices.

(4) Consumption Coverage Gap is the effect of incorporating imputed rents and in-kind government health-care and medical transfers. Note that Coverage Difference is derived by subtracting Price Difference and Conventional Real Consumption from Welfare Change, and thus also includes the specification error mentioned in Equation (14).

**Table 2** presents the decomposition results for the changes in economic welfare for each age group between the base year (2005) and the final year (2021), based on Equation (14). Relative to the traditional real consumption measure, our welfare index increases by 0.061 in logarithmic terms (6.3%), while traditional real consumption declines by 0.118 in logarithmic terms (11.2%), producing a net difference of 0.179 in logarithmic terms (a 17.5 percentage-point gap). Of this gap, 0.102 points (10.7%) derive from the choice of deflator, and 0.077 points (8.0%) stem from including in-kind transfers and imputed rents.

Although the effects are smaller, we observe a similar pattern for households in their 40s. However, among older households—particularly those in their 70s—the traditional real consumption measure displays a larger welfare increase than our welfare indicator. In this case, both the price index effect and the commodity coverage effect are negative but minimal, exerting little overall influence.

**Table 3** compares the results obtained under the assumption of the Cobb–Douglas type utility function presented in Equation (15) with our welfare measure in **Table 2**. As dis-

**Table 3:** Comparison of the Real Actual Consumption and the Cobb–Douglas Quantity Index

| | Under 40 | 40–49 | 50–59 | 60–69 | 70–79 |
|---|---|---|---|---|---|
| (5) Incl. actual consumption for med | 1.0630 | 1.0244 | 1.0249 | 1.0338 | 0.9980 |
| (6) Cobb–Douglas quantity index | 1.0665 | 1.0270 | 1.0271 | 1.0375 | 0.9992 |
| $\alpha^a$: Expenditure share on medical care | 0.1473 | 0.1357 | 0.1686 | 0.2244 | 0.3049 |

*Note:* Values correspond to the 2021 data. The values in line (5) are a restatement of line (1), "Welfare Change," from Table 2. Line (6) presents values calculated using the Cobb–Douglas quantity index. The expenditure share on medical care ($\alpha^a$) varies across age groups and is shown in the last row.

cussed, the consumption of medical services that the government provides free of charge or at low cost may not be consistent with a standard expenditure minimization problem, making it challenging to accurately approximate the cost-of-living index using a superlative index. By employing a Cobb–Douglas type utility function and directly using quantity information to calculate changes in utility, we can circumvent this issue.[16]

As shown in the table, the quantity index based on the Cobb–Douglas assumption closely resembles (5) based on the superlative index, indicating that our main results remain essentially unchanged.

In summary, changes in in-kind government transfers and imputed rents in Japan between 2005 and 2021 contributed to higher economic welfare for younger households, while having negligible or no effect on average welfare for older households.

# 5 Implications of In-Kind Transfers

In addition to being crucial for evaluating redistribution policies, in-kind government transfers have significant implications for understanding household economic behavior.

First, in lifecycle models of household consumption, liquidity constraints play an important role. An increase in in-kind transfers can mimic the effect of increasing household income, effectively easing these constraints. If these transfers increase, households may re-

[16]The quantity information for medical services is obtained by deflating the NMCE with the SNA medical expenditure deflator.

duce their monetary consumption and redirect resources toward savings, even when their nominal income remains constant—an outcome that is difficult to interpret without considering changes in in-kind transfers. Thus, analyzing shifts in in-kind transfers may provide valuable insights into the dynamics of liquidity constraints.

Second, persistent expansions of health care-related in-kind transfers can weaken the incentives of younger generations to save for future medical expenses. By lowering the anticipated costs of health care and long-term care, these transfers diminish the need for precautionary savings, thereby reshaping optimal consumption and saving decisions. This underscores the importance of considering not only the magnitude of in-kind transfers, but also the specific areas they target, when examining household economic behavior.

Third, in-kind transfers may affect intrahousehold resource allocation and labor supply decisions. For instance, starting in 2024, the Tokyo Metropolitan Government offered free tuition at Tokyo Metropolitan University for residents, thereby potentially influencing their work-education choices. Similarly, the introduction of free childcare for children aged three and older in 2019 may have influenced household time allocation and labor market participation. Such policies can encourage previously stay-at-home caregivers to enroll their children in kindergartens and join the workforce, thereby altering household dynamics.

Finally, changes in the scale of in-kind transfers can influence the marginal utility of aggregate consumption goods, thereby affecting estimation results of the Euler equation, which links intertemporal consumption choices to interest rates. When in-kind transfers intersect with labor supply considerations, their effects become more complex and far-reaching, shaping multiple facets of household behavior and overall economic welfare.

While this analysis focuses on Japan, similar issues are likely to arise in other countries undergoing significant shifts in in-kind transfers. Traditional measures of real consumption may not fully capture changes in economic welfare. Key improvements involve incorporating age-specific data on in-kind government benefits—particularly in health care—and acquiring category-specific household expenditure data to construct attribute-specific superlative indices.

In countries where the consumer price index (CPI) includes imputed rents and publishes attribute-specific CPIs, it becomes possible to develop attribute-specific real consumption

measures that integrate imputed rents using CPI weights. Even without detailed in-kind transfer data, combining attribute-specific expenditure information and imputed rents can yield results that deviate from those obtained via conventional measures. These findings highlight the potential for creating alternative consumption and welfare indicators that more accurately reflect evolving economic conditions.

# 6 Conclusion

This study demonstrates that incorporating government-provided in-kind transfers, imputed rents, and age-specific price indices into measures of real consumption can alter the measurement of consumption trends across age groups. By moving beyond conventional methods that rely on a uniform CPI and exclude significant non-monetary contributions, the refined approach presented here offers a more nuanced and accurate depiction of economic welfare.

Our findings indicate that while conventional measures suggest a sharp decline in real consumption among younger households in Japan, our refined approach instead reveals a notable increase. By accounting for in-kind transfers and imputed rents, and employing age-specific cost-of-living indices, the gap between measured and acquired consumption narrows, resulting in a more comprehensive assessment of household well-being. These results highlight the importance of tailoring deflators to household characteristics and broadening the scope of consumption measures to include nonmonetary benefits. In doing so, this study enhances our understanding of intergenerational consumption dynamics and underscores the critical influence of public policy on household welfare. Future research should extend these methods to other forms of government-provided in-kind transfers and apply them across a wider range of socioeconomic contexts.

Several important avenues for future exploration remain. For instance, we have not considered the effects of in-kind government transfers relating to compulsory education and long-term health-care insurance. Additionally, although we rely on the medical care deflator used by the SNA, it may not fully capture quality improvements in medical services, as suggested by Cutler et al. (1998). Addressing these challenges—particularly by including a broader range of in-kind transfers and improving quality adjustments in medical care—represents a

promising direction for future research.

Finally, while this paper has focused on developing and measuring a new real consumption series, the implications of this approach for testing theoretical models of household consumption and informing macroeconomic analysis remain unexplored. Important questions include the extent to which in-kind government transfers affect the validity of the permanent income hypothesis among younger generations, and whether these transfers influence macrolevel savings, capital accumulation, and long-term economic growth. These offer fertile ground for future study.

# Appendix 1

# Estimation of Imputed Rent for Owner-Occupied Housing

In this study, we independently estimate the imputed rent of owner-occupied housing based on the following survey items from the FIES:

- Housing tenure (owner-occupied, private rental housing, public rental housing, employee housing)
- Total floor area of the dwelling ($m^2$)
- Private rent (yen/month)
- Residential area

## (Step 1)

We extract households living in private rental housing and estimate the following rent function for each year (2005–2021):

$$\ln(Rent_{i,t}) = \alpha_{0,t} + \alpha_{1,t} \ln(Floor_{i,t}) + \beta_{0,t} D_{i,t} + \beta_{1,t} B^1_{i,t} + \beta_{2,t} B^2_{i,t} + \beta_{3,t} B^3_{i,t} \tag{A.1}$$

Households that meet the following conditions are excluded:

(i) Private rent is zero.

(ii) The top 1% in private rent (yen/month), floor area ($m^2$), and private rent per square meter (yen/$m^2$) for each year.

### (Variables)

$i$ : Household ID

$t$ : Year (2005–2021)

*Rent* : Private rent (yen/month)

*Floor* : Total floor area of the dwelling ($m^2$)

$D$ : Dummy for Tokyo Special Wards and ordinance-designated cities

**Regional Block**

$B^1$ : Tokyo

$B^2$ : Saitama, Chiba, Kanagawa

$B^3$ : Kyoto, Osaka, Hyogo

$B^4$ : Other Prefectures (Base category)

The descriptive statistics for each variable are presented in **Table A.4**. The classification of the four regional blocks is based on the estimation method used for the rent function in the National Survey of Family Income and Expenditure (conducted every 5 years by the MIAC; renamed the National Survey of Family Income, Consumption, and Wealth in 2019). However, to ensure the sample size is sufficient, we do not estimate the rent function by region but instead employ regional block dummies.

## (Step 2)

Using the estimated coefficients from **Table A.5**, we estimate the imputed rent for owner-occupied households as follows:

$$\textit{Imputed Rent}_{i,t} = \exp\left(\widehat{\alpha}_{0,t} + \widehat{\alpha}_{1,t}\ln(\textit{Floor}_{i,t}) + \widehat{\beta}_{0,t}D_i + \widehat{\beta}_{1,t}B_i^1 + \widehat{\beta}_{2,t}B_i^2 + \widehat{\beta}_{3,t}B_i^3\right) \quad \text{(A.2)}$$

Regarding the estimates from (A.2), we compared our results with those provided by the MIAC to validate the reliability of our results. Separately from the FIES, the MIAC conducts a large-scale survey on consumption and income (the National Survey of Family

Income and Expenditure) every 5 years, covering all of Japan. Through the "order-made tabulation" scheme, a paid service, researchers can access survey data with tailored variables and aggregation methods based on their specific requests. For this study, we focused on owner-occupied households with two or more members to align with the scope of the FIES. Using this largescale survey, we obtained prefectural-level data on the imputed rent for owner-occupied housing. In **Figure A.1**, the horizontal axis represents the values provided by the MIAC, while the vertical axis shows our estimation results. Each marker in the graph corresponds to one of Japan's 47 prefectures. For all surveyed years, the correlation coefficient is approximately 0.9, indicating that our imputation method performs well.

**Table A.4:** Descriptive Statistics of Variables Used for Estimating the Rent Function

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Private Rent (unit: yen/month) | 64858.547 | 24088.447 | 15,480 | 200,000 |
| Floor Area (unit: $m^2$) | 63.471 | 20.962 | 25 | 165 |
| D: Dummy for Tokyo Special Wards and ordinance-designated cities | 0.286 | 0.452 | 0 | 1 |
| Dummy for Regional Block | | | | |
| $B^1 : Tokyo$ | 0.052 | 0.221 | 0 | 1 |
| $B^2 : Saitama, Chiba, Kanagawa$ | 0.089 | 0.285 | 0 | 1 |
| $B^3 : Kyoto, Osaka, Hyogo$ | 0.076 | 0.265 | 0 | 1 |
| $B^4 : Other Prefectures$ | 0.783 | 0.412 | 0 | 1 |
| $N$ | 172,762 | | | |

Note: The data is pooled from 2005 to 2021. Private rent is in nominal terms.

**Table A.5:** Estimation Results for the Rent Function

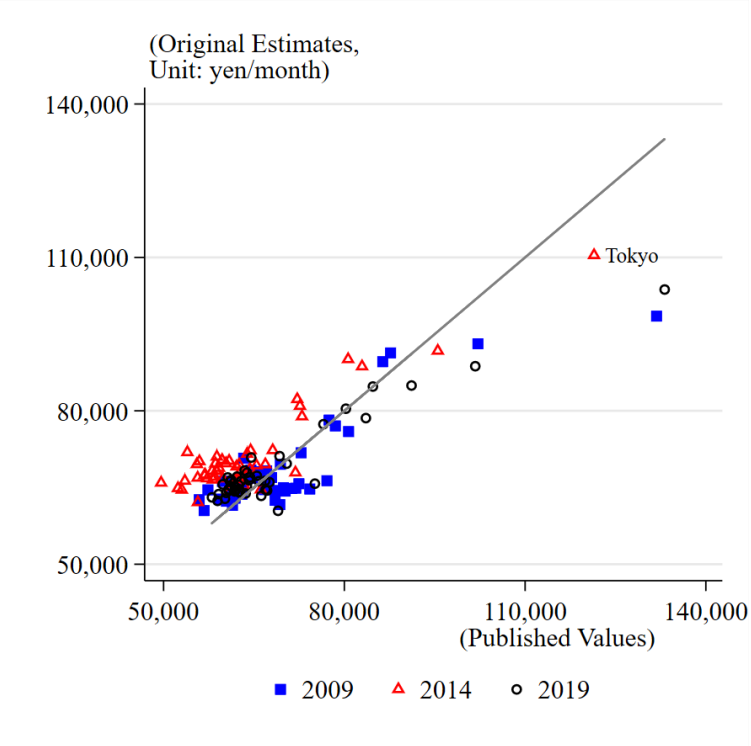
| | 2009 | 2014 | 2019 |
|---|---|---|---|
| ln(Floor) | 0.208*** | 0.256*** | 0.206*** |
| | (0.010) | (0.010) | (0.012) |
| D: Dummy for Tokyo special wards and ordinance-designated cities | 0.158*** | 0.106*** | 0.136*** |
| | (0.007) | (0.007) | (0.008) |
| Dummy for Regional Block | | | |
| $B^1 : Tokyo$ | 0.393*** | 0.504*** | 0.445*** |
| | (0.016) | (0.013) | (0.018) |
| $B^2 : Saitama, Chiba, Kanagawa$ | 0.346*** | 0.304*** | 0.285*** |
| | (0.010) | (0.012) | (0.013) |
| $B^3 : Kyoto, Osaka, Hyogo$ | 0.157*** | 0.187*** | 0.181*** |
| | (0.013) | (0.015) | (0.015) |
| Constant | 10.057*** | 9.869*** | 10.078*** |
| | (0.039) | (0.041) | (0.051) |
| Observations | 10753 | 9725 | 8437 |
| Adjusted $R^2$ | 0.257 | 0.269 | 0.214 |

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Due to space constraints, only the results for 2009, 2014, and 2019 are presented. However, estimations were conducted for the entire period (2005–2021).

**Figure A.1:** Prefecture-Level Average Imputed Rent for Owner-Occupied Housing: Independent Estimate vs. Published Values




Note : The published values at the three time points were obtained from the following surveys: National Survey of Family Income and Expenditure (2009 and 2014), National Survey of Family Income, Consumption, and Wealth (2019).

# Appendix 2

# Comparison of Several Index Number Formulas

In the following figure and table, we present the values of various price indices, including the official CPI:

- Laspeyres index
$$P_L = \frac{\sum_i p_{i1} q_{i0}}{\sum_i p_{i0} q_{i0}}$$

- Paasche index
$$P_P = \frac{\sum_i p_{i1} q_{i1}}{\sum_i p_{i0} q_{i1}}$$

- Fisher index
$$P_F = \sqrt{P_L \cdot P_P}$$

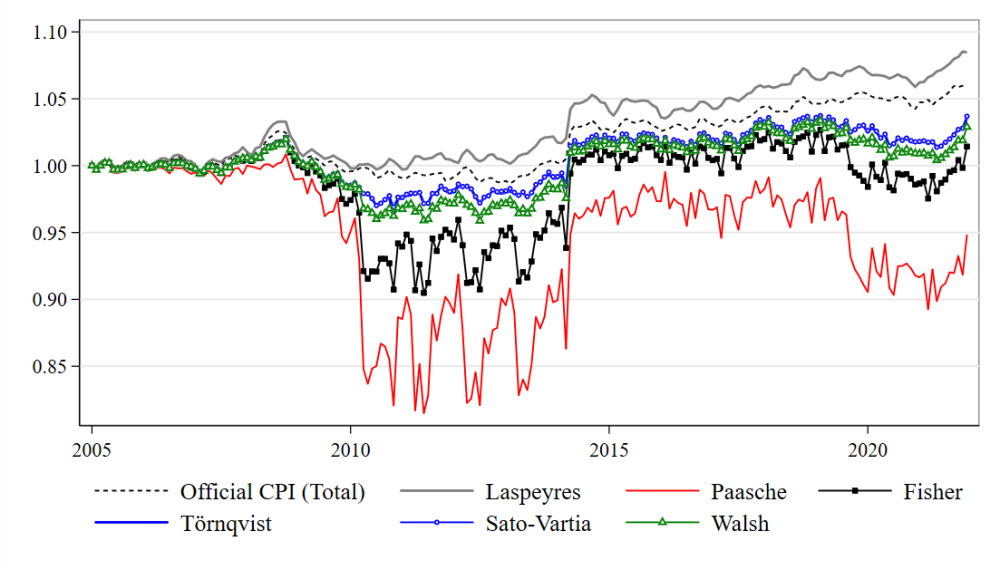
- Törnqvist index
$$\ln P_T = \sum_i \frac{w_{i0} + w_{i1}}{2} \ln \frac{p_{i1}}{p_{i0}}$$
where the expenditure share $w_{it}$ is defined as:
$$w_{it} = \frac{p_{it} q_{it}}{\sum_j p_{jt} q_{jt}}, \quad t = 0, 1$$

- Sato–Vartia index
$$\ln P_{SV} = \sum_i s_i \ln \frac{p_{i1}}{p_{i0}},$$
where $s_i$ is defined as follows:
$$g_i = \begin{cases} \frac{w_{i1} - w_{i0}}{\ln w_{i1} - \ln w_{i0}}, & \text{if } w_{i1} \neq w_{i0}, \\ w_{i1}, & \text{if } w_{i1} = w_{i0}, \end{cases}$$
$$s_i = \frac{g_i}{\sum_i g_i}.$$

- Walsh index

$$P_W = \frac{\sum_i p_{i1}\sqrt{q_{i0}q_{i1}}}{\sum_i p_{i0}\sqrt{q_{i0}q_{i1}}}$$

**Figure A.2:** Comparison of Price Indices




Note: Except for the Official CPI, the figures are our estimates based on information from the elementary-level CPI and the FIES. The items covered by our estimation include the items from the FIES and the imputed rent for owner-occupied houses estimated independently. In addition, as the expenditure amount for tatami replacement cost was 0 at only one point during the analysis period, this item has been excluded from the calculations in this figure.

**Table A.6:** Excerpt of Price Index Values

| | CPI (Total) | Fisher | Törnqvist | Sato–Vartia | Walsh |
|---|---|---|---|---|---|
| 2005 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 2006 | 0.9990 | 1.0007 | 1.0008 | 1.0008 | 1.0008 |
| 2007 | 0.9990 | 0.9975 | 0.9977 | 0.9977 | 0.9977 |
| 2008 | 1.0062 | 1.0052 | 1.0060 | 1.0061 | 1.0060 |
| 2009 | 1.0062 | 1.0000 | 1.0034 | 1.0035 | 1.0028 |
| 2010 | 0.9959 | 0.9743 | 0.9848 | 0.9853 | 0.9835 |
| 2011 | 0.9907 | 0.9395 | 0.9753 | 0.9763 | 0.9675 |
| 2012 | 0.9918 | 0.9448 | 0.9801 | 0.9812 | 0.9716 |
| 2013 | 0.9887 | 0.9478 | 0.9797 | 0.9812 | 0.9716 |
| 2014 | 1.0021 | 0.9565 | 0.9906 | 0.9919 | 0.9822 |
| 2015 | 1.0268 | 1.0079 | 1.0193 | 1.0206 | 1.0159 |
| 2016 | 1.0258 | 1.0042 | 1.0147 | 1.0158 | 1.0120 |
| 2017 | 1.0309 | 1.0040 | 1.0180 | 1.0192 | 1.0151 |
| 2018 | 1.0443 | 1.0198 | 1.0313 | 1.0328 | 1.0289 |
| 2019 | 1.0464 | 1.0230 | 1.0347 | 1.0361 | 1.0319 |
| 2020 | 1.0536 | 0.9842 | 1.0247 | 1.0263 | 1.0164 |
| 2021 | 1.0474 | 0.9867 | 1.0178 | 1.0181 | 1.0089 |

Note: The values in this table are an excerpt of the price index data for January of each year, as shown in Figure A.2.

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