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Jun Nagayasu

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Center for Data Science and Service Research
Graduate School of Economic and Management
Tohoku University
27-1 Kawauchi, Aobaku
Sendai 980-8576, JAPAN

Intra-temporal Substitution between Tradable and Nontradable Goods: Evidence from the Japanese Cross-sectional Survey Data

Jun Nagayasu[†]

Abstract

Using survey-based Japanese household data, this study estimates the elasticity of intra-temporal substitution (EIS) between tradable and nontradable goods. Thus, this research is related to the Backus-Smith puzzle (1993), which states the nontradable sector and low substitution between these goods are the reasons for nonconformance to the purchasing power parity theory. Among other conclusions, we confirm that consumption behavior differs among households with different social backgrounds. Furthermore, we find that the EIS is overestimated when household characteristics and time dimensions are not taken into account in the consumption function. Indeed, the EIS is low and close to zero when properly estimated, thereby confirming a cause of the Backus-Smith puzzle. Based on these findings, we conclude that prices are less decisive factors in determining the consumption composition than what the standard economic theories predict. In contrast, social factors such as age, cohort, and family size are more directly associated with consumers' allocation of goods and services.

Keywords: Intra-temporal elasticity of substitution, tradable and nontradable goods, economic goods and services, survey-based household data, Japan
JEL classification: D1

[†]Tohoku University, Graduate School of Economics and Management, Address: 27-1 Kawauchi, Aoba-ku, Sendai, Miyagi 980-8576 JAPAN, Email: jun.nagayasu.d8@tohoku.ac.jp, Tel: +81 22 795 6265, Fax: +81 22 795 6270 The previous version was presented at the Household Finance Conference, the Macroeconomics Workshop at Kyoto/Osaka Universities, and the biannual meetings of the Japan Society of Monetary Economics and the Japanese Economic Association. I would like to thank Yuji C. Horioka, Hiroshi Fujiki, Hirokazu Ishise, Yukinobu Kitamura, Shin-ichi Nishiyama, Arito Ono, Masakatsu Okubo, Takayuki Tsuruga, and Takashi Unayama for constructive comments. I also thank Gabriel Cordoba for research assistance. All remaining errors are mine. This research was supported by grants-in-aid for Scientific Research from the Japan Society for the Promotion of Science (Kakenhi Kiban (C) No. 17K03796).

1 Introduction

Consumers often make economic and financial decisions subject to budget constraints, and such decisions are related to the selection of goods and services to maximize their utility. Moreover, conventional economic theory suggests that, while making consumption decisions, prices are often assumed to play a key role. The relationship between prices and the selection of goods and services is summarized in the elasticity of substitution.

Academic research considers two types of substitution. The substitution among economic goods at a particular point in time is called the *intra*-temporal substitution. On the other hand, *inter*-temporal substitution refers to how consumption should be allocated over time and is the major focus of previous studies using time series data. This trend in the previous literature appears to reflect in part the data availability and the difficulties in the estimation of inter-temporal substitution using standard statistical methods. That is, while estimates of intra-temporal elasticity are robust, the magnitude of inter-temporal substitution is reportedly biased unless the intra-temporal substitution is considered (Ogaki and Reinhart 1998).

In the past, such substitution has often been between the two types of economic goods and services: (1) durables versus non-durables (e.g., Ogaki and Reinhart 1998, Pakos 2011), (2) goods purchased by governments versus goods purchased by private consumers (e.g., Bailey 1971, Ho 2001, Okubo 2003, Auteri and Costantini 2010), (3) domestic versus imported goods (Amano and Wirjanoto 1996), and (4) tradable versus nontradable goods (Cashin and McDermott 2003). These studies are often based on a theoretical derivation that maximizes the utility of a representative agent (Ogaki and Reinhart 1998, Ogaki and Park 1992), and such a theoretical framework is shown to be consistent with the time series properties of consumption data. Therefore, statistical methods such as cointegration (Engle and Granger 1987) have been popular analytical tools in the past.

Against this background, we shall analyze the elasticity of *intra*-temporal substitution (EIS) in Japan, particularly between tradable and nontradable goods, using survey-based household data. Microdata analysis is known to be more reliable than the study of aggregate data. Results from analysis of macroeconomic data suffer from aggregation bias and suggest a lower value for the elasticity of inter-temporal substitution than microdata analysis even when demographic factors are considered (Attanasio and Weber 1993). Blundell et al. (1994) show that excess sensitivity of consumption to income growth, often observed in aggregate data, can be eliminated when household characteristics are included in microdata analysis. Thus, this paper departs from previous studies in the following aspects. First, to the best of our knowledge, this study is one of the first to use household consumption data to estimate the elasticity of substitution in Japan. Microdata allow us to consider household characteristics, which have been ignored in previous studies, in the elasticity estimation. This is expected to be important as differences in consumption patterns across different life stages have been reported by researchers (Modigliani 1966, Skinner 1988), and dramatic demographic changes have been taken place in Japan. The Cashin and Unayama (2016) study is one exception that analyzed substitution elasticity using survey data. They analyzed the impact of the consumption tax increase in April 1997 on consumption behavior, and concluded that the elasticity of *inter*-temporal substitution was nil in Japan. It suggests that despite perceived increases in prices, consumers did not rush out to purchase goods prior to the implementation of the tax rate hike.[1]

Second, as can be seen from the aforementioned literature, this is one of the very first studies to analyze the degree of substitution between tradable and nontradable goods. This distinction is important in economic analysis because it modifies the theoretical predictions in many fields of economics. For example, nontradable goods are used to explain violations of the purchasing power parity (PPP) condition. Balassa (1964) and Samuelson (1964) have argued that different wage growth in nontradable sectors across countries is attributable to the persistent deviation of real exchange rates from the PPP, known as the Balassa-Samuelson puzzle. Furthermore, Backus and Smith (1993) state that, despite progress in removing cross-border barriers, the poor relationship between real exchange rates and consumption (the Backus-Smith (BS) puzzle) arises because nontradable goods are not considered in economic theory and there is low substitution between tradable and nontradable goods. Nagayasu (2017) confirms that the BS puzzle is caused mainly by the imperfect substitutability between tradable and nontradable goods, rather than the exchange rate fluctuation.

[1]There are many studies using microdata in other countries. For example, Blundell et al. (1994) and Crossley and Low (2011) studied household characteristics and time-varying nature in the study of inter-temporal substitution, respectively, in the UK. Similarly, using the UK microdata, Attanasio and Browning (1995) studied demographic effects on inter-temporal substitution.

2 Substitution between tradable and non-tradable goods

This section explains the theoretical definition of substitution following the analytical framework often used in previous studies.[2] That is, consumers maximize their utility, which is a function of consumption. Closely following Amano and Wirjanto (1998), a household (i) is assumed to maximize the following expected utility function ($U(\cdot)$) that is based on consumption (C).

$$E\left[\sum_{t=0}^{\infty}\beta^{t}U(C_{it}^{Tr},C_{it}^{NTr})\right] \tag{1}$$

where E is an expectations operator, and the consumption of tradable and non-tradable goods are denoted as C_t^{Tr} and C_t^{NTr} respectively. $\beta \in (0,1)$ is a subjective discount factor, and subscript t denotes time ($t = 1, ..., T$). To derive the EIS, Zeldes (1989) and Blundell et al. (2008) use the following constant-elasticity-of-substitution utility function with a parameter of household-specific tastes, θ_{it}:

$$U(C_{it}^{Tr},C_{it}^{NTr}) = \frac{u(C_{it}^{Tr},C_{it}^{NTr})^{1-\gamma}}{1-\gamma}\exp(\theta_{it}) \tag{2}$$

where γ ($\gamma > 0$) is the coefficient of relative risk aversion (RRA). $1/\gamma$ is the *inter*-temporal elasticity of substitution between tradable and nontradable goods. Generally, previous studies report a large γ (typically less than 10) and the inter-temporal elasticity is not equal to one as predicted by a time-separable utility model (Constantinides 1990). Moreover, we assume that the taste parameter comprises time and household-specific elements (η_t and δ_i) as well as random components ($\omega_{it} \sim N(0, \sigma_\omega^2)$).

$$\theta_{it}^{Tr} = \eta_t^{Tr} + \delta_i^{Tr} + \omega_{it}^{Tr}$$
$$\theta_{it}^{NTr} = \eta_t^{NTr} + \delta_i^{NTr} + \omega_{it}^{NTr}$$

Therefore, there is no need for taste variables to be identical for tradable and non-tradable goods. Eq. (2) without θ_{it} is often used to describe a steady-state condition in economic growth models, which makes this utility function very popular in macroeco-

[2]The intra-temporal elasticity of substitution is hereinafter referred to simply as elasticity of substitution unless specified.

nomic analyses. Using the above mentioned notations, the consumption index becomes equal to:

$$u(C_{it}^{Tr}, C_{it}^{NTr}) = [\emptyset \exp(\theta_{it}^{Tr})(C_{it}^{Tr})^{1-\alpha} + (1-\emptyset)\exp(\theta_{it}^{NTr})(C_{it}^{NTr})^{1-\alpha}]^{\frac{1}{1-\alpha}} \quad (3)$$

where $\alpha > 0$. Parameter $\emptyset$ is a weight attached to tradable goods ($\emptyset \in (0,1)$). This index represents the utility function being additively separable into two types of goods, and becomes a Cobb-Douglas-type function when α approaches one. This index is homothetic and assumes no income effect. The non-homothetic index may be more plausible in a general setting, but this classical assumption is maintained here because our analysis is based on cross-sectional data and this assumption makes our results comparable with those in previous studies. In these preference specifications, $1/\alpha$ is the EIS (Ogaki and Reinhart 1998, Amano and Wirjanto 1998), which is of interest here,[3] and the parameter of substitution is theoretically positive.

Based on these equations, optimal consumption behavior can be stated by analyzing the first-order condition, which implies that the relative price equals the ratio of marginal rates of substitution.

$$\frac{p_{it}^{Tr}}{p_{it}^{NTr}} = \frac{\frac{\partial U}{\partial C_{it}^{Tr}}}{\frac{\partial U}{\partial C_{it}^{NTr}}} = \frac{\emptyset \exp(\theta_{it}^{Tr})(C_{it}^{Tr})^{-\alpha}}{(1-\emptyset)\exp(\theta_{it}^{NTr})(C_{it}^{Nr})^{-\alpha}} \quad (4)$$

This equation can be expressed in the natural logarithmic form as Eq. (5), and shows that the absence of household characteristics results in the model misspecification. Critically, Eq. (5) assumes a homogenous EIS even though taste factors are included.

$$\ln\left(\frac{p_{it}^{Tr}}{p_{it}^{NTr}}\right) = \ln\left(\frac{\emptyset}{1-\emptyset}\right) + (\theta_{it}^{Tr} - \theta_{it}^{NTr}) + \alpha \ln\left(\frac{C_{it}^{NTr}}{C_{it}^{Tr}}\right) \quad (5)$$

To estimate the homogeneous EIS, we re-express Eq. (5) in terms of consumption, as will be discussed in Section 4. Moreover,we consider several combinations of social factors that are expected to affect tastes and the consumption composition, and the robustness of our findings will be examined by considering financial wealth of households, which is absent in the above mentioned theoretical model.

[3]Using these two types of substitution, Amano and Wirjanto (1998) show the Edgeworth-Pareto conditions.

3 Data

Our analysis requires consumption and price data. Survey-based consumption data are obtained from the *Zenkoku Shohi Jittai Chosa* (National Survey of Family Income and Expenditure, NSFIE) compiled by Japan's Ministry of Internal Affairs and Communications (MIAC). This survey has been conducted every five years since 1959 to gather detailed information about the consumption patterns of residents in Japan. In fact, the NSFIE is the most comprehensive dataset of consumption data in Japan with a sample size of about 50000 households for each year. Consumption consists of the consumption of durable, semi-durable, and non-durable goods as well as services. Generally, durable goods are those that are expected to last more than one year, and the distinction between durable and semi-durable goods is made according to price. Following the traditional approach (Balassa 1964), the first three are treated in this study as tradable goods and services as nontradable goods.[4] In addition to expenditures, the NSFIE contains information about income and social backgrounds such as age, gender and employment status. The NSFIE is also comprehensive in terms of geographical coverage and includes about 5000 geographical units (cities, towns, and villages).

Cross-sectional household-level NSFIE data are disseminated to the public from the Statistics Bureau of Japan's MIAC for four years (1989, 1994, 1999, and 2004). There is another dataset, the *Kakei Chousa* (Family Income and Expenditure Survey, FIES), which is conducted monthly, but its sample size is only about 9000 households, and furthermore household-level data from this survey are not disseminated to the public. Thus, our dataset covers the bubble period (through February 1991) and the post-bubble period (March 1991 onwards). During the bubble period, prices of financial and nonfinancial assets rose in an unprecedented manner, and consumers perceived that such price increases in financial assets and real estates were permanent. On the other hand, the post-bubble period was an era of low economic growth and low inflation, and consumers did not have bright prospects for the future. Therefore, our sample periods are long enough to cover significant shifts in consumers' living environments that potentially become factors to

[4]This dataset has been used to analyze savings behavior in Japan by many researchers (e.g., Hayashi 2011, Kitamura et al. 2001). They provide detailed descriptions of this dataset and also point out the deficiencies in it especially for the analysis of savings.

change consumption decisions.[5]

This survey is conducted during September-November each year for households of two or more persons and during the October-November of each year for single-person households. Single-person households account for only a small fraction of our dataset (Table 1), and the average number of household members is around three, typically two parents and a child (Figure 1). The largest household in our sample contains seven members. Interestingly, large (more than five people) as well as two-person families tend to reside in the countryside, while there is more likelihood of four-person families in metropolitan areas (Tokyo, Osaka, and Nagoya regions). On the other hand, there are no clear regional differences in terms of the distribution of single-person families.

Household heads are typically aged around 45 to 49 years, and the majority (90%) are male, and 40% of households live in one of the three metropolitan areas. Moreover, 70% of households have at least one member with a full-time job[6] and a simple average annual salary of 6.7 million yen, with savings of 11.4 million yen. Income profiles of households are also presented in Figure 2 by time periods, age groups and generations (cohorts). It shows that income distribution is skewed to the left, indicating that more consumers earn less than the average income. Furthermore, consumers aged between 55–59 (Age7), which is more or less in line with the retirement age in Japan, earned the highest.

It is interesting to note that income inequality widens along with age and cohort (Table 2). The heads of household in the same cohort can be identified because age profiles are reported in 5-year intervals, and the survey is conducted every 5 years. Greater inequality is usually found among the older people and generations, perhaps due to differences in work experiences. Because older people generally possess more hands-on and relevant experience, their income is expected to be high. However, not all people are promoted at work as the amount of accumulation of job skills is rather specific to individual workers. As a result, a society is normally less egalitarian in line with age and cohort. Nevertheless, by international standards, Japan has been considered as historically egalitarian. The Gini coefficient for Japanese labors between 35 and 65 years old from 2009 to 2013 is reported as 0.329 while that for U.S. labors it is reported as 0.453 (Aizawa et al. 2017). The

[5]For these four years, annual inflation (YOY) was 2.3, 0.7, -0.3 and 0.0 percent, and the overnight uncollateralized call money rate was 5.117, 2.196, 0.058 and 0.001%.

[6]The distinction between full-time and part-time jobs is important because of job security and social benefits aspects, which are often not available to part-time workers in Japan.

inequality results from differences in education and marital status in Japan, and education and working hours in the United States. Occupations and positions in companies are in turn influenced by educational attainment and work experience.

Figure 3 plots the proportion of services in the total consumption according to key grouping variables, and suggests heterogeneity in consumption composition. For instance, small families tend to spend proportionally more on services, and there is a notable difference in consumption patterns between single-person households and families. Furthermore, the very poor and rich households tend to consume services proportionally less than the middle-income groups. A large portion of the consumption of the poor is in necessary goods for living, which are often considered non-durable goods. The wealthy households purchase enough services and spend more on expensive economic goods. Similarly, households in urban areas and female households spend more on services, reflecting the fact that more services are available in larger cities.

In addition to consumption data, we obtain price data from the CPI compiled by the MIAC (see Table 1). To maintain consistency with the consumption data, and given the particular months of the year during which the NSFIE is conducted, we use the price data for August.[7] In this manner, we attempt to mitigate the potential endogeneity problem in our specification, which was overcome by the use of cointegration techniques in previous time series analyses. Due to lack of detailed residential information of households in the NSFIE, we use the CPI of Tokyo to represent prices in the metropolitan areas, and the national average as a proxy for prices in other regions.[8]

4 Intra-temporal substitution

4.1 The standard specification of EIS (Model 1)

Initially, we estimate the classical EIS specification (Amano and Wirjanto 1998), thereby assuming the constant RRA across households and no taste shift variables ($\theta_{it}^{Tr} - \theta_{it}^{NTr}$). However, unlike some previous studies, it is more natural to express Eq. (5) in terms of prices in a highly competitive market, in which prices are often given to consumers.

[7]The general results remain unchanged when the CPI for September is used.

[8]Our results may suffer because of a lack of variation in regional prices, but this problem is mitigated by our analysis of price ratio as opposed to price level.

Furthermore, because our data are cross-sectional, the subscript t disappears from our estimation model. We name this specification Model 1.

$$\ln\left(\frac{C_i^{NTr}}{C_i^{Tr}}\right) = -\frac{1}{\alpha}\left[\ln\left(\frac{\emptyset}{1-\emptyset}\right)\right] + \frac{1}{\alpha}\ln\left(\frac{p_i^{Tr}}{p_i^{NTr}}\right) \tag{6}$$

This equation shows the magnitude of changes in consumption patterns (i.e., from tradable to nontradable goods or vice versa) in response to price differences. Therefore, parameter $1/\alpha$ measures the extent to which consumption patterns have changed due to increases in relative prices. When $\alpha > 0$, an increase in the prices of tradable goods leads to a decline in their consumption and/or a rise in that of nontradable goods. Random shocks to preferences frequently considered in time series analysis, are assumed to be captured in a fixed effects term in cross-sectional analyses.

In a more compact form that is directly linked with statistical analysis, Eq. (6) can be expressed as:

$$\tilde{\mathbf{y}} = a\tilde{\mathbf{x}} + \mathbf{u} \tag{7}$$

where $\tilde{\mathbf{y}} = y_i - N^{-1}\sum_{i=1}^{N} y_i$ and $\tilde{\mathbf{x}} = x_i - N^{-1}\sum_{i=1}^{N} x_i$ represent relative consumption and the price ratio, respectively. This data transformation results in $E(\tilde{\mathbf{y}}) = E(\tilde{\mathbf{x}}) = E(\mathbf{u}) = 0$. The residual $\mathbf{u}$ is normally distributed with a constant variance (σ^2). We estimate this equation using the Bayesian estimation approach (the random-walk Metropolis-Hastings sampling method) that allows us to impose easily a non-negativity parameter constraint on the EIS.

In order to obtain posterior distributions of parameters, Model 1 assumes the prior distributions (a ~Uniform(0,100) and $\sigma^2 \sim IG(0.01,\ 0.01)$), and several statistics are calculated in order to summarize the posterior. We can evaluate a parameter size by examining the posterior mean, median, 95% credible interval, and standard deviation of the marginal posterior distributions. In addition, the Monte Carlo standard error (MCSE) is presented to show the accuracy of the posterior mean estimates; the small MCSE indicates good sampling. The difference in the mean and medium values indicates the asymmetry in the posterior distributions.

Table 3 summarizes these statistics of the EIS for a variety of household groups.

The estimation with iterations of 10000 and burn-in of 3000 suggests that the EIS is 5.433 without considering social indicators. This is slightly higher than the EIS reported in Cashin and McDermott (2003). Their estimates, using macroeconomic data for five advanced countries (Australia, Canada, NZ, the UK, and the US), range from 0.6 to 3.5. However, such estimates may not be very accurate as they may be sensitive to the household characteristics. Previous studies on consumption point out that consumption behavior is heterogeneous among consumers, and thus the consumption composition is likely to differ according to consumers' characteristics such as family size (e.g., Irvine 1978). Therefore, we estimate the elasticity using Eq. (7) by consumer type in terms of residential location, gender, employment status, and family size.

Indeed, the EIS appears to differ among households. It is reported to be higher in the metropolitan areas and for males. Furthermore, the level of substitution is higher for those in employment. This result may be contrary to the expectation that poor people are more sensitive to prices, but is consistent with prior academic studies (Havranek et al. 2015) on inter-temporal substitution. They interpret this result as suggesting that non-employed persons purchase only really necessary goods and thus may be living already below the subsistence levels at which relative prices are less relevant to their consumption decisions. On the other hand, wealthy consumers tend to purchase relatively more luxurious goods that are not necessities and thus have potential alternatives. More significant discrepancies in the EIS are reported between single-person households and those with two or more persons. Our finding of heterogeneous EIS among different households here implies that social factors need to be included in the EIS estimation.

4.2 The EIS and social factors (Model 2)

Recognizing the importance of social factors in consumption decisions, we re-estimate the EIS based on Eq. (8) that adds social backgrounds of households ($\Theta_i = \theta_i^{Tr} - \theta_i^{NTr}$) as explanatory variables in Model 1. This specification is in line with previous studies (e.g., Zeldes 1989, Blundell et al. 2008) and is equivalent to allowing household-specific terms in the cross-sectional analysis, and is referred to as Model 2.

$$\ln\left(\frac{C_i^{NTr}}{C_i^{Tr}}\right) = -\frac{1}{\alpha}\left[\ln\left(\frac{\emptyset}{1-\emptyset}\right) + \Theta_i\right] + \frac{1}{\alpha}\ln\left(\frac{p_i^{Tr}}{p_i^{NTr}}\right) \tag{8}$$

where Θ_i is specified as a function of social factors for each household i.

$$\Theta_i = a + bGender_i + cFamily\, size_i + dAge_i + eAge_i^2 + fWorkers\, in\, family_i + u_i$$

The choice of these social variables is similar to that of Zeldes (1989) who considers family size, age and squared age of household heads, but we also use other variables such as Gender and Workers in the family. Notably, we consider differences in taste among genders and also the unique characteristics of families with more than one workers (Workers in family), typically households of two-parent working families that have been steadily increasing over the years, reaching 10 million in 2007. Since the average annual salary of such households is around 7 million yen in total, individual workers in two-parent working families are often relatively poor, and they may find it difficult to live on a single source of income. Among social indicators, age is important in the analysis of the Japanese economy because demographic changes have accelerated over recent decades; while the birth rate remains low (1.46), Japanese longevity is one of the highest in the world: 80.79 for males and 87.05 for females in 2015. As a result, Japan has become one of the most aging countries in the world, and this phenomenon has created social problems such as a decreasing labor force and inadequate social care funding. To tackle these issues, the typical retirement age has been gradually increasing from 55 years in the 1970s and 1980s to 60 years in 2016, even for those employed by large corporations. Furthermore, the government is encouraging firms to increase the retirement age further to 65 years by introducing the Law of Stabilization of Employment of Older Persons in 2013.

Generally, consumption decisions are considered to be closely related to life stages. The life cycle hypothesis (Modigliani 1966) asserts that young people save for their retirement, and they dis-save for living when they become pensioners. Skinner (1988) has demonstrated that due to uncertainty in future interest rates and earnings, precautionary saving accounts for more than half of total life time saving. Although his paper focused on savings, it has strong implications for household decisions as consumption is the other side of the coin, and the (dis-)saving behaviors is consistent with smoothing consumption in response to expected changes in their future income. Their efforts to smooth consumption and maximize utility are also reflected in the intra- and inter-temporal elasticity of substitution.

Because Eq. (8) is a linear equation, we maintain the same prior distribution for the parameters as those used in Table 3; however, additional parameters (a, b, c, d, e,and$f$) of explanatory variables related to social factors are assumed to follow the normal distribution (Normal(0,10000)) as there is no strong theoretical predicted sign for these parameters. In other words,

$$
\begin{aligned}
a, b, c, d, e, f &\sim N(0, 10000) \\
EIS &\sim Uniform(0, 100) \\
\sigma^2 &\sim IG(0.01, 0.01)
\end{aligned}
$$

Table 4 summarizes the results from the specification with and without time dummies (1994, 1999 and 2004). Ceteris paribus, our results suggest that, females, and small and young families tend to spend proportionally more on services. Furthermore, when there are more than two people working in a family, there is a tendency for the household to consume proportionally more tradable goods. Because 95% credible intervals of these parameters do not cross zero, we can interpret these parameters as statistically significant, thereby implying the rejection of the null hypothesis of a homogenous consumption composition among household groups.

The EIS is also reported to differ among models with different compositions of social factors; however, when both social factors and time dummies are included in the specification, the EIS estimates are consistently close to zero. Then, which EIS is the most reliable? For this purpose, we choose the best model on the basis of the Deviance Information Criterion (DIC) estimated by the Markov Chain Monte Carlo method (MCMC). The DIC is widely used in Baynesian analyses to describe the model accuracy, and similar to the information criteria for time series (e.g., Akaike information criterion), the small value of this criterion indicates that the model is a best fit to the data.[9] The deviance for observed data y is $-2 \log p(y|\vartheta_{Bayes})$, where ϑ_{Bayes} is the posterior mean and $p(.)$ is

[9]The DIC is probably the most standard criterion, and, despite potential problems, has yielded the expected positive statistics in our analysis.

the log predictive density and is theoretically positive and less than one. Then, the DIC is often calculated as:

$$DIC = -2 \log p(y|\vartheta_{Bayes}) + 2p_{DIC}$$

where p_{DIC} is the effective number of parameters. We check which variable is the best for grouping our observations.

According to the DIC, the model comprising time dummies and the social indicators, which includes Gender, Family size, Age, Age^2, and Workers in family, has the smallest value of the DIC (Table 5). Therefore, the EIS of 0.004 seems to be most supported by the data, and the medium value also shows a similar EIS. Figure 4 presents convergence of EIS estimates and ensures their statistical reliability. Thus, together with Cashin and Unayama (2016) who report evidence of the insignificant elasticity of inter-temporal substitution, our study suggests a marginal importance of price mechanisms in Japan during our sample period. Given the significant parameter size for household characteristics in Eq. (8), social backgrounds of households are more influential over consumer decisions than prices. To check the robustness of our elasticity estimates, we shall next calculate the EIS between non-durables and services as well as among cohorts. Furthermore, the EIS will be investigated taking into account financial backgrounds of households.

5 Further analyses

5.1 Elasticity between non-durables and services

Our definition of tradable goods consists of durable, semi-durable, and non-durable goods. It is well known that consumers do not purchase durable goods as often as non-durable goods because durables last longer than non-durables. Therefore, consumer decisions to purchase durable and semi-durable goods may not be as sensitive to price changes as non-durable ones. Indeed, most consumption studies distinguish between durable and non-durable goods, and they focus on the latter because prices of non-durables are expected to react to economic shocks more in ways that are more consistent with economic theory. Thus, we estimate the EIS between non-durable goods and services based on Model 2.

The results with or without time dummies are summarized in Table 6, and there are two messages in this table. First, like the EIS analysis of tradables and services, females and small families tend to consume services relatively more than non-durable goods, ceteris paribus. Similarly, there is a tendency for older people to spend more on tradable goods when time dummies are included. Second, the EIS between non-durables and services is reported to be slightly higher than the EIS between tradables and services. This is an expected outcome since durable and semi-durable goods, which are less sensitive to prices, are removed from this analysis. However, such discrepancies between the EISs are marginal, since the EIS between services and the non-durable (0.001 and 0.014) stays within the 95% credible interval of the EIS between services and tradable goods (i.e., between 0.000 and 0.015 in Table 4). The EIS between non-durable goods and services in Japan is thus close to zero and is even lower than the EIS (=0.18) between non-durables and service flowing from the stocks of durable goods in the USA (Pakos 2011).

5.2 Cohort effects

Next, we estimate the EIS between tradable goods and services according to the cohort. Here, in order to make the estimation feasible, households in the same cohort groups are identified by combining two cohorts in Table 1; for example, the youngest cohort (Cohort0+1) is created by combining Cohort 0 and Cohort 1 in the same year. As a result, we have six cohort groups in this analysis. Otherwise, the same specifications and prior distributions in Table 4 would be again employed in this subsection. Table 7 reports that younger cohorts are relatively more sensitive to prices; their EIS is higher than that of older cohorts. But, again, differences in the EIS among cohorts are generally insignificant, given that the EIS of the youngest cohort (0.021) often stays within the 95% credible interval of older cohorts.

5.3 Income effects

So far, we have assumed that income effects are nil in our estimation; however, these effects are often reported to have significant impacts on substitution (e.g., Pakos 2011). Pakos argued that the income effects are particularly related to durable goods that can be regarded as non-necessities. Therefore, we investigate the EIS between tradables and services in the non-homothetic context. But since we have only cross-sectional data and cannot trace consumption decisions of identical households over time, our theoretical model is not suitable for showing how the households change consumption patterns in response to increases in their own income. Rather, income effects should be interpreted here as to what extent the EIS changes when households with different financial wealth are examined. In order to address this question, we use two types of financial information (i.e., annual salary and savings) and classify households into 10 categories based on quantiles of financial data (see Table 1). Then, assuming income effects are insignificant among households in the same category, we estimate Model 2 for each group of income and savings.

Table 8 suggests that there are differences in the EIS among household groups of different financial positions. The models classified by annual salary (Income0 to 9) show that the EIS ranges from 0.010 to 0.188. The highest EIS is obtained from the third least wealthy household group, and the lowest EIS is from the third wealthiest household group. The lower middle income groups tend to have a higher EIS than the other income groups. This is consistent with conventional expectations, but it differs slightly from Havranek et al. (2015), who assumed a linear relationship between inter-temporal substitution and financial wealth and concluded that substitution increases along with financial wealth. Our results imply that the least wealthy households do not change consumption composition much because most of their consumption are necessities; the EIS of the wealthy households is low as they can afford price changes.

We can draw a similar conclusion from EIS estimates among different savings groups. Again, there are variations in these EIS estimates. High EIS is reported for the lower middle savings groups, and low EIS is reported for the most and least wealthy savings groups. A similar non-linear relationship between the EIS and financial position is also confirmed by household wealth (Wealth) defined as the total of annual salary and savings. This comprehensive definition of wealth is closely related to the concept of permanent income, in which savings act as a buffer to smooth consumption. Unlike in cohort analysis, the EIS differences are significant because the mean values of EIS go beyond the 95% credible intervals of other groups on many occasions. This confirms the significant income effects in the EIS estimation.

Finally, we note that aggregation bias exists even in household data analyses, although it is often discussed in the context of macroeconomic analysis. The aggregation bias exists in our cohort analysis but is less pronounced in the income effect analysis, in which households are disaggregated in more detail (i.e., 10 groups). This can be seen by comparing the results in Tables 4, 7, and 8, all of which are obtained from Model 2 and thus, household data. These tables show that the EIS estimates from the disaggregate analysis in which households are classified for example by financial standing, are greater than the ones from the whole household samples. The classification method to group households (i.e., by annual salary, savings, and wealth) does not influence this outcome. It has been discussed that this aggregation bias arises from an a priori assumption of homogeneous parameters in aggregate data analysis (e.g., Attanasio and Weber 1993), and this explanation still appears valid in household-level analyses. However, the fact that the EIS is very small remains unchanged and thus, our results pose a question about the role of a price mechanism in the allocation of services and tradable goods in Japan.

6 Summary

Using a survey-based Japanese household data, we estimated the EIS between tradable and nontradable goods and revealed several interesting differences in the consumption patterns of households with different social backgrounds. In particular, we find the EIS as very low in Japan based on several models and show that the EIS is substantially overestimated without consideration of household characteristics and time dimensions. Indeed, when these factors are taken into account, the EIS becomes very close to zero, thereby questioning a role of a price mechanism in Japan. The insignificant role of prices in household decisions is confirmed by taking into account cohort and income effects as well as examining the EIS between services and non-durable goods.

This result signals the direction of future research on international economics. As discussed in the introductory section, this study sheds light on the Backus-Smith puzzle: the weak relationship between exchange rates (relative prices) and the consumption ratio results from the low EIS between tradables and nontradables. Our estimates for intra-temporal substitution suggest that the EIS between tradables and nontradables differs according to financial standing of households: the lower middle groups tend to have a higher EIS. But more importantly, our empirical evidence implies that services cannot often be considered as substitutes for tradable goods even among these families. The low rate of substitution between them, regardless of financial standing of households, justifies Backus and Smith (1993) explaining a violation of the PPP and poses a question about the price mechanism, which is a center of economics. Moreover, given the fact that social factors are found to be very important elements in household decisions on consumption allocation, researchers seem to have relied too heavily on the EIS to explain a violation of the purchasing power parity condition.

Appendix

The NSFIE does not collect information of non-Japanese households and students due to difficulties in collecting information of their income and expenditures. Otherwise, in principle, all households in the NSFIE are used for the analysis. However, those who do not possess all (dependent and independent) variables in our specifications, are excluded from this study, and household heads considered in this study are those who are more than and including 20 years old. In this survey, the annual salary of more than 25million yen is recorded as 25 million, and similarly the savings of more than 95 million yen is recorded as 95 million. NSFIE data is available for purchase from the Statistics Center, the Ministry of Internal Affairs and Communication (MIAC), and is not transferable to third parties following the regulation of the MIAC.

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Table 1: Descriptive summary and explanations of survey data

Variables	Obs	Mean	Std. Dev.	Min	Max	Comments
Durable goods	192,014	0.076866	0.171349	0	1	A fraction out of total consumption
Semidurable goods	192,014	0.171345	0.18873	0	1	A fraction out of total consumption
Nondurable goods	192,014	0.434025	0.198527	0	1	A fraction out of total consumption
Services	192,014	0.317764	0.20056	0	1	A fraction out of total consumption
Gender	192,599	0.105343	0.306996	0	1	Female=1, Male=0
No. of family members	192,599	3.303283	1.422743	1	7	People
Metropolitan area	192,599	0.401264	0.490156	0	1	Metropolitan=1, Otherwise=0
						Age 20-24=0
						Age 25-29=1
						Age 30-34=2
Age group	192,599	6.741333	2.806542	0	14	:
						Age 80-84=13
						Age +85=14
						Generation of Age group =0 in 1989=0
						Generation of Age group=1 in 1989 =1
Generation(cohort) group	187,639	5.26673	2.681678	0	11	:
						Generation of Age group=11 in 1989 =11
Employment status	192,599	0.750731	0.432591	0	1	Employed=1, Otherwise=0
Annual salary	192,599	6748259	4005816	10000	2.50E+07	Yen
Savings	144,802	1144.092	1470.187	0	9500	0000 Yen
						Income0 if Salary < 2640000
						Income1 if 2640000 ≤Salary < 3560000
						Income2 if 3560000 ≤Salary <4320000
						Income3 if 4320000 ≤Salary <5090000
Income group				0	9	Income4 if 5090000 ≤Salary <5950000
						Income5 if 5950000 ≤Salary <6850000
						Income6 if 6850000 ≤Salary <7970000
						Income7 if 7970000 ≤Salary < 9400000
						Income8 if 9400000 ≤Salary <1.18e+07
						Income9 if Salary≥1.18e+07
						Saving0 if savings <430000
						Saving1 if 430000 ≤savings <1970000
						Saving2 if 1970000 ≤savings <3440000
						Saving3 if 3440000 ≤savings <5000000
Savings group				0	9	Saving4 if 5000000 ≤savings <6900000
						Saving5 if 6900000 ≤savings <9300000
						Saving6 if 9300000 ≤savings <12700000
						Savin7 if 12700000 ≤savings <18330000
						Saving8 if 18330000 ≤savings<29840000
						Saving9 if savings≥29800000
Workers in family				0	1	Workers=0 if non household head is employed, otherwise Workers=1

Notes: Note: The sample periods are 1989, 1994, 1999 and 2004.

Table 2: Inequality within age and generation groups

Household group	Gini coefficient	Household group	Gini Coefficient
Age0	0.275	Cohort0	0.239
Age1	0.218	Cohort1	0.242
Age2	0.217	Cohort2	0.246
Age3	0.219	Cohort3	0.251
Age4	0.225	Cohort4	0.259
Age5	0.236	Cohort5	0.274
Age6	0.247	Cohort6	0.299
Age7	0.270	Cohort7	0.330
Age8	0.303	Cohort8	0.345
Age9	0.347	Cohort9	0.354
Age10	0.351	Cohort10	0.383
Age11	0.362	Cohort11	0.405
Age12	0.379		
Age13	0.408		
Age14	0.430		

Notes: The inequality statistics are Gini coefficient. The higher values indicate more serious inequality. Based on four year observations. Household groups are defined in Table 1.

Table 3: The substitution elasticity between tradable and nontradable goods based on micro data

	Mean	Std Dev	MCSE	Median	95% cred interval		obs
Full	5.433	0.045	0.001	5.432	5.344	5.522	161414
σ^2	1.260	0.004	0.000	1.260	1.251	1.268	
Metro	5.808	0.069	0.001	5.807	5.674	5.945	62810
σ^2	1.148	0.006	0.000	1.148	1.136	1.161	
Nonmetro	5.201	0.058	0.001	5.200	5.087	5.317	98604
σ^2	1.330	0.006	0.000	1.330	1.319	1.342	
Female	3.735	0.134	0.002	3.735	3.471	3.998	16599
σ^2	1.141	0.012	0.000	1.141	1.117	1.166	
Male	5.627	0.047	0.001	5.626	5.533	5.721	144815
σ^2	1.272	0.005	0.000	1.272	1.263	1.281	
Employed	5.608	0.057	0.001	5.607	5.496	5.719	117049
σ^2	1.363	0.006	0.000	1.363	1.352	1.374	
Unemployed	5.061	0.071	0.001	5.061	4.924	5.201	44365
σ^2	0.987	0.007	0.000	0.987	0.975	1.000	
Single person households	0.892	0.149	0.002	0.892	0.601	1.183	10829
σ^2	0.982	0.013	0.000	0.982	0.956	1.008	
Family	5.778	0.047	0.001	5.777	5.685	5.871	150585
σ^2	1.273	0.005	0.000	1.273	1.264	1.282	

Notes: Based on Model 1. The MSCE stands for the Monte Carlo standard error.

Table 4: Intra-temporal substitution

	Mean	Std. Dev.	MCSE	Median	95% Cred. Interval		Mean	Std. Dev.	MCSE	Median	95% Cred. Interval	
	No time dummy						Time dummies					
Elasticity	5.724	0.041	0.001	5.723	5.646	5.804	0.003	0.003	0.000	0.002	0.000	0.011
Gender	0.033	0.008	0.000	0.033	0.017	0.049	0.051	0.006	0.000	0.051	0.040	0.062
Family size	-0.046	0.002	0.000	-0.046	-0.050	-0.042	-0.037	0.002	0.000	-0.037	-0.041	-0.034
Age	-0.113	0.002	0.000	-0.113	-0.117	-0.108	-0.167	0.002	0.000	-0.167	-0.171	-0.163
Age^2	0.007	0.000	0.000	0.007	0.007	0.008	0.010	0.000	0.000	0.010	0.010	0.010
σ^2	1.003	0.003	0.000	1.003	0.996	1.009	0.740	0.003	0.000	0.740	0.735	0.745
Elasticity	5.725	0.040	0.001	5.725	5.648	5.803	0.004	0.004	0.000	0.003	0.000	0.015
Gender	0.028	0.008	0.000	0.028	0.012	0.045	0.019	0.013	0.004	0.018	-0.004	0.044
Family size	-0.042	0.002	0.000	-0.042	-0.046	-0.038	-0.040	0.002	0.000	-0.040	-0.043	-0.037
Age	-0.110	0.002	0.000	-0.110	-0.114	-0.106	-0.158	0.002	0.000	-0.158	-0.163	-0.154
Age^2	0.007	0.000	0.000	0.007	0.007	0.008	0.010	0.000	0.000	0.010	0.009	0.010
Workers in family	-0.034	0.005	0.000	-0.034	-0.044	-0.023	-0.024	0.005	0.001	-0.024	-0.033	-0.014
σ^2	1.002	0.004	0.000	1.002	0.996	1.009	0.739	0.003	0.000	0.739	0.734	0.744

Note: Based on Model 2. Time dummies are for 1994, 1999, and 2004.

Table 5: Deviance information criterion

Model	No time dummy	Time dummies
Gender, Family size, Age, Age^2	474358.6	423573.3
Gender, Family size, Age, Age^2, Workers in family	474321.9	423443.4

Notes: Based on Model 2.

Table 6: Intra-temporal substitution between non-durables and services

	Mean	Std Dev	MCSE	Median	95% cred interval	
No time dummy						
Elasticity	0.001	0.001	0.000	0.001	0.000	0.003
Gender	0.087	0.007	0.000	0.087	0.074	0.101
Family size	-0.058	0.002	0.000	-0.058	-0.061	-0.055
Age	0.028	0.002	0.000	0.028	0.024	0.031
Age^2	-0.005	0.000	0.000	-0.005	-0.006	-0.005
Workers in family	-0.047	0.005	0.000	-0.047	-0.055	-0.037
σ^2	0.693	0.002	0.000	0.693	0.688	0.698
Time dummies						
Elasticity	0.014	0.014	0.001	0.009	0.000	0.051
Gender	0.067	0.007	0.001	0.067	0.053	0.080
Family size	-0.056	0.002	0.000	-0.056	-0.060	-0.053
Age	-0.017	0.002	0.000	-0.018	-0.022	-0.012
Age^2	-0.003	0.000	0.000	-0.003	-0.003	-0.002
Workers in family	-0.041	0.005	0.001	-0.041	-0.051	-0.033
σ^2	0.678	0.002	0.000	0.678	0.674	0.683

Notes: Based on Model 2.

Table 7: Intra-temporal substitution between tradables and services, by cohorts

Household group	Mean	Std Dev	MCSE	Median	95% cred interval	
Cohort0+1	0.021	0.020	0.001	0.014	0.001	0.076
Cohort2+3	0.015	0.014	0.001	0.011	0.000	0.052
Cohort4+5	0.006	0.006	0.000	0.004	0.000	0.023
Cohort6+7	0.005	0.005	0.000	0.004	0.000	0.019
Cohort8+9	0.008	0.008	0.000	0.005	0.000	0.028
Cohort10+11	0.006	0.006	0.001	0.005	0.000	0.025

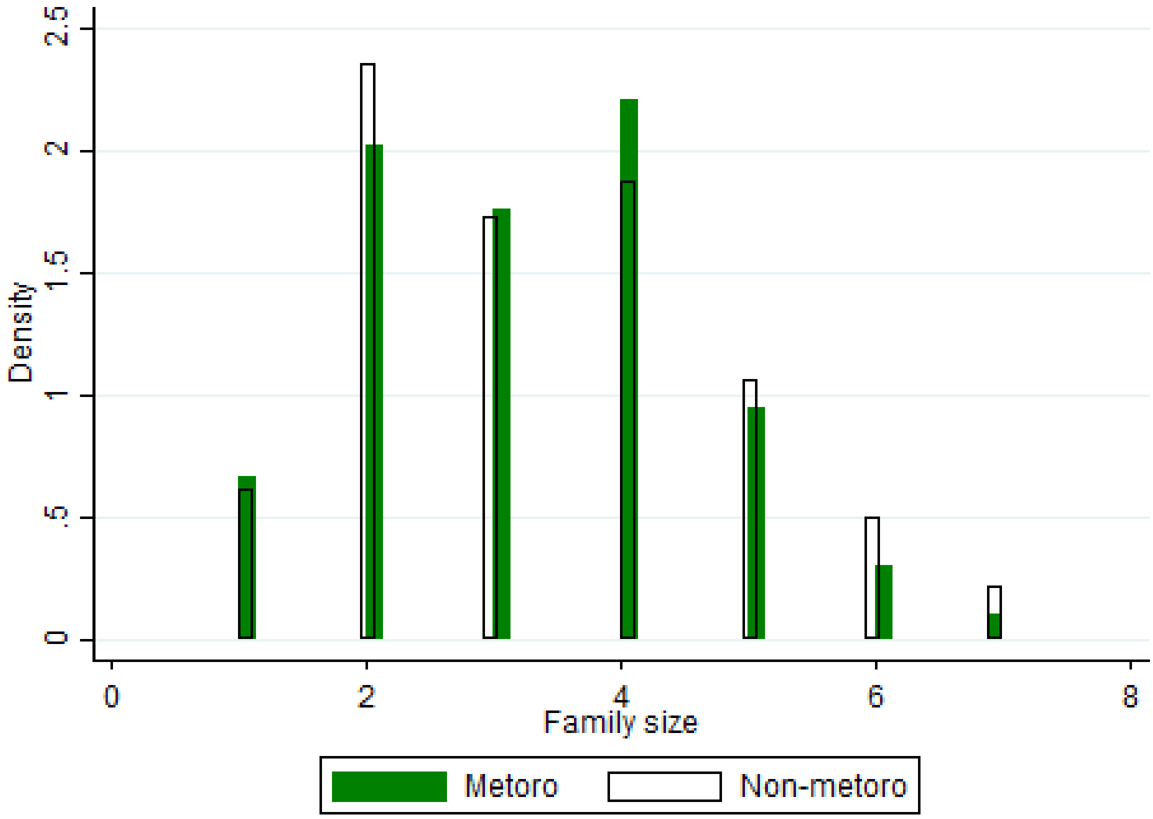
Notes: Note: Based on Model 2. Two cohorts are grouped together. Cohort 0+1 indicates a generation combined Cohort 0 with Cohort 1, defined in Table 1. Time dummies and social indicators such as Gender, Age, Age^2, and Workers in family are included.

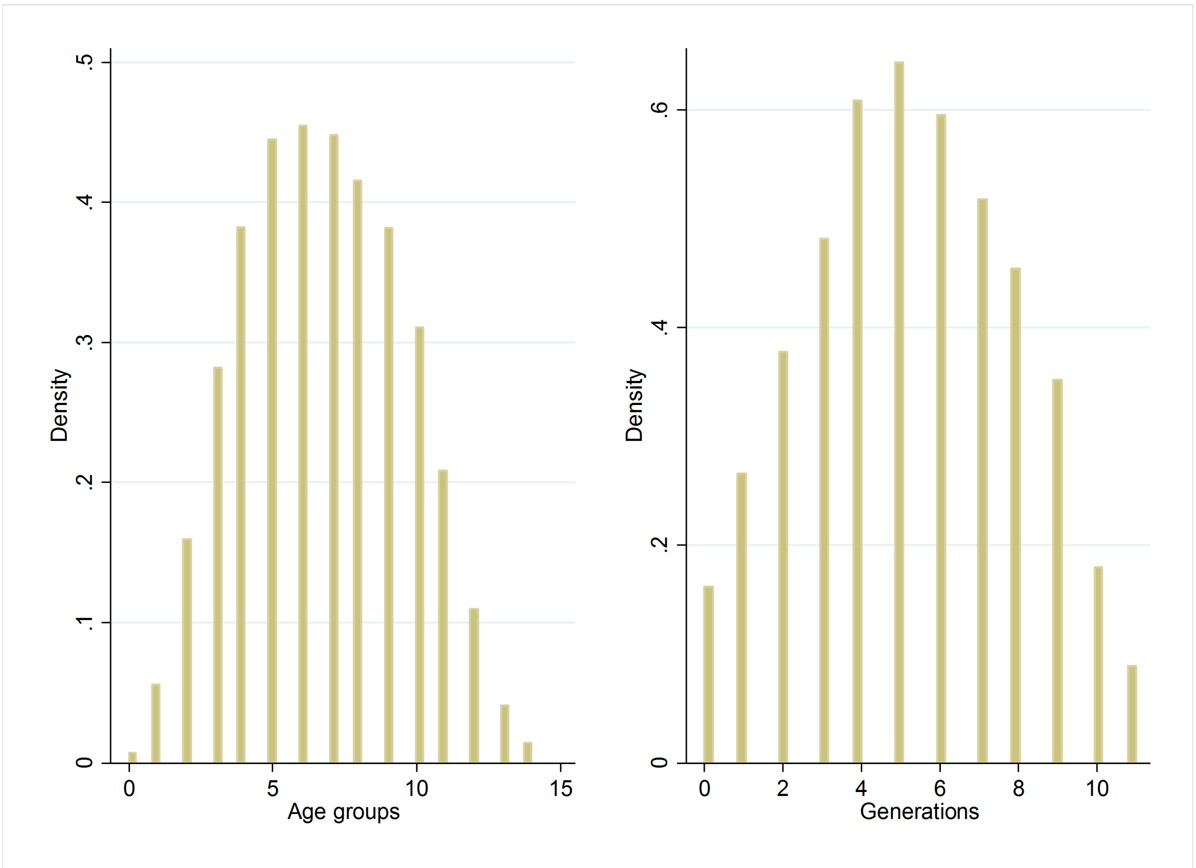
Table 8: Intra-temporal substitution between tradables and services, by financial positions

Household group	Mean	Std Dev	MCSE	Median	95% cred interval	
Income0	0.051	0.049	0.002	0.035	0.001	0.184
Income1	0.078	0.074	0.003	0.055	0.002	0.277
Income2	0.188	0.152	0.013	0.152	0.007	0.566
Income3	0.157	0.125	0.016	0.129	0.006	0.461
Income4	0.089	0.083	0.004	0.063	0.003	0.311
Income5	0.072	0.067	0.003	0.052	0.003	0.248
Income6	0.054	0.050	0.002	0.039	0.002	0.180
Income7	0.010	0.010	0.000	0.007	0.000	0.038
Income8	0.030	0.029	0.001	0.021	0.001	0.109
Income9	0.022	0.021	0.001	0.015	0.000	0.079
Saving0	0.036	0.036	0.001	0.024	0.001	0.132
Saving1	0.322	0.198	0.020	0.309	0.021	0.728
Saving2	0.211	0.169	0.014	0.167	0.010	0.651
Saving3	0.070	0.067	0.005	0.051	0.002	0.261
Saving4	0.091	0.087	0.004	0.063	0.003	0.320
Saving5	0.038	0.037	0.001	0.026	0.001	0.139
Saving6	0.057	0.051	0.002	0.042	0.002	0.187
Saving7	0.039	0.036	0.002	0.028	0.001	0.133
Saving8	0.028	0.027	0.001	0.020	0.001	0.098
Saving9	0.021	0.021	0.001	0.015	0.000	0.079
Wealth0	0.166	0.132	0.012	0.131	0.005	0.493
Wealth1	0.222	0.163	0.017	0.189	0.010	0.597
Wealth2	0.122	0.116	0.010	0.088	0.004	0.431
Wealth3	0.113	0.100	0.005	0.085	0.003	0.377
Wealth4	0.057	0.058	0.003	0.038	0.002	0.222
Wealth5	0.060	0.060	0.003	0.041	0.001	0.218
Wealth6	0.012	0.013	0.001	0.008	0.000	0.046
Wealth7	0.019	0.018	0.001	0.013	0.001	0.067
Wealth8	0.042	0.042	0.002	0.029	0.001	0.151
Wealth9	0.054	0.049	0.003	0.040	0.002	0.182

Notes: Based on Model 2. Household groups are defined in Table 1, and the number attached to variables indicates a quantile.Time dummies and social indicators such as Gender, Age, Age^2, and Workers in family are included.

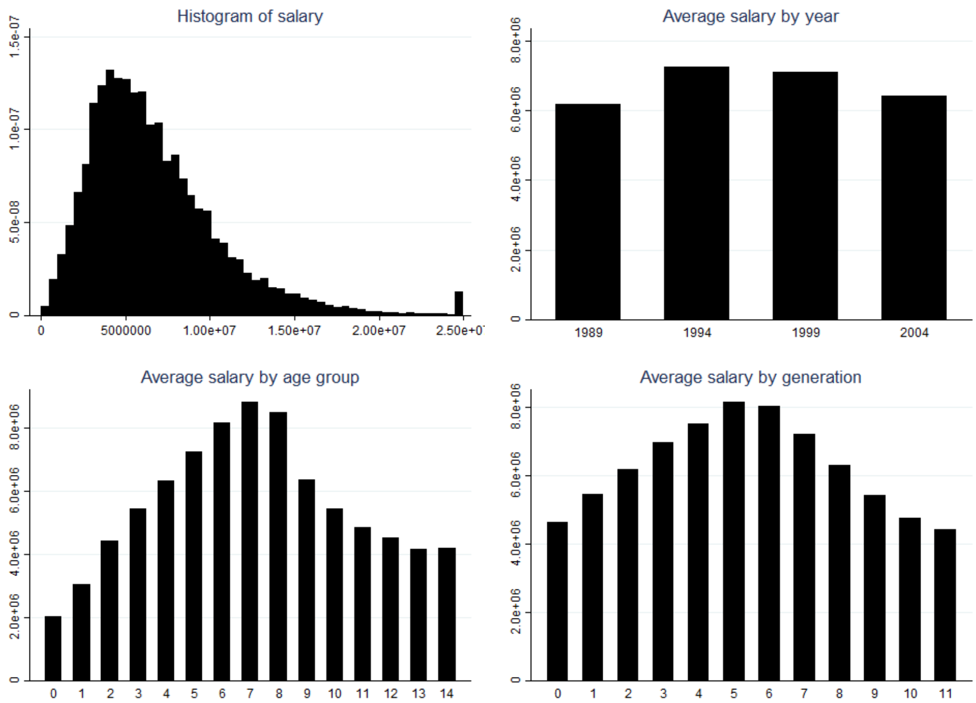
Figure 1: Consumers by family size, age group, and generation





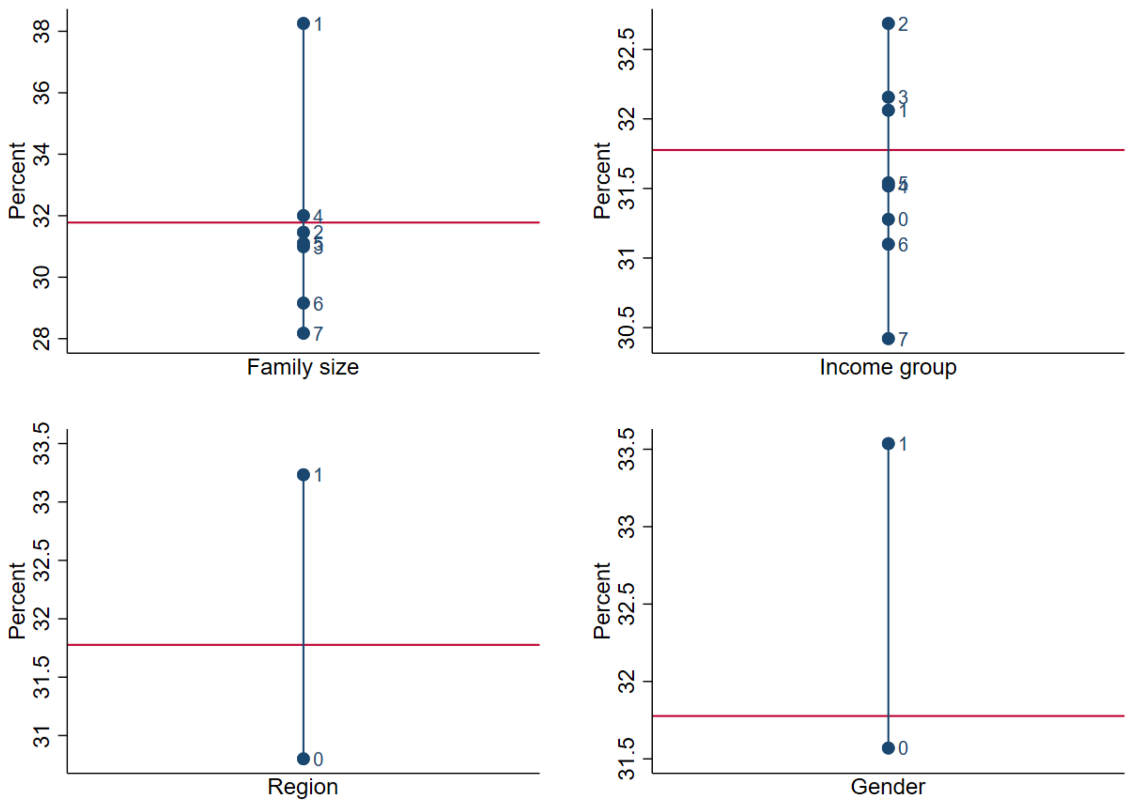
Notes: Household groups are defined in Table 1.

Figure 2: Average salary



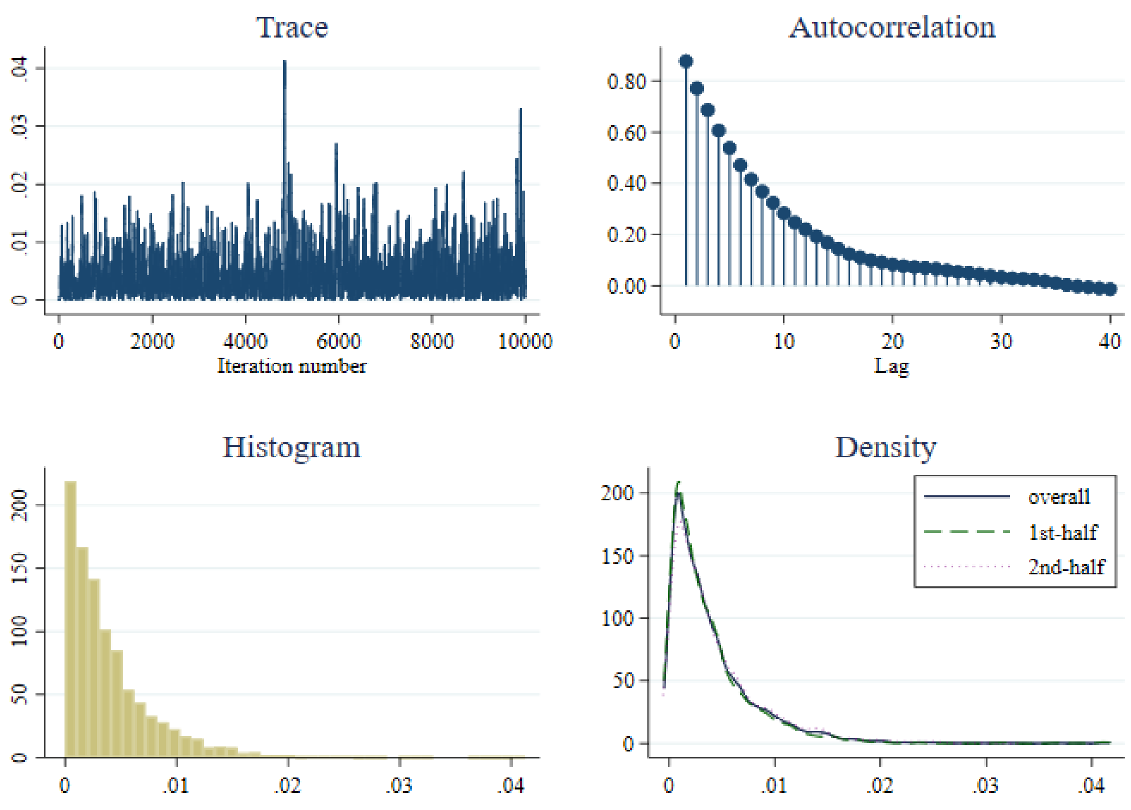
Notes: Household groups are defined in Table 1.

Figure 3: The proportion of services by groups



Notes: Household groups are defined in Table 1.

Figure 4: Intra-temporal substitution



Notes: Based on Model 2.