Demand System Analysis of Coffee in the Japanese Households
（日本の家計におけるコーヒーの需要システム分析）

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Demand System Analysis of Coffee in the Japanese Households
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TABLE OF CONTENTS

LIST OF TABLES

Chapter 2

Chapter 3

Chapter 4

LIST OF APPENDIX

CHAPTER 1: Introduction

1.1 Background

Coffee is one of the most demanded agricultural commodities in the world and each day an average of 2.25 billion cups of coffee are consumed worldwide (Daviron, Ponte, 2005; ICO). Since 1970, global coffee consumption has almost doubled by 91 % reaching 8.1 million tons in 2010 (ICO). More recently from the year 2011 to 2014, global coffee consumption has been increasing at an average annual growth rate of 2.4%, reaching 149.8 million bags for the year 2014 (ICO, 2015b).

Constituting more than 70% of the total coffee demand are the industrialized economies (ICO). Japan is one of the industrialized nations that saw its coffee demand increase significantly over the years. Currently, it is ranked fourth behind the United States, Brazil, and Germany (ICO, 2015a). Japan's consumption has increased from the year 2000 to 2014, 6.62 million kg to 7.49 million kg bags (Statista, 2015). In addition, as far as coffee retail price is concerned, Japan ranks higher than most of the importing nations, with approximately 5 US $/kg from 1990 to 2010. As comparison, within the same time period, coffee retail price for the United States was around 1.5 US $/kg (ICO, 2011). Japan's consumption per capita, however, has remained steady at 3.5 kg (ICO, 2015a).

In the Japanese non-alcoholic beverage market, coffee beverage has the fourth largest demand behind tea beverage (5.4 billion liters), carbonated beverage (3.6 billion liters) and fluid milk (3.0 billion liters) with an overall coffee beverage consumption of 2.9 billion liters in 2013. Within the coffee beverage market, instant coffee holds the largest segment with 2.12 billion liters followed by canned coffee with 661.6 million liters, coffee containing milk beverage with 147.9 million liters, and coffee containing soft drinks with 21.3 million liters for the year 2013 (Japan Soft drink Association, 2014).

As a popular beverage, several studies over the years, have analyzed the demand for coffee in different countries. Some of these studies include those of: Goddard and Akiyama (1989), Okunade (1992), Yeboah (1992), Sellen and Goddard (1997), Houston, Santilla, and Marlowe (2003) and Gebrehiwot and Daloonpate (2012).

These studies analyzed the income and price elasticities for coffee categories using various econometrics models. However, with regards to coffee demand analysis in Japan, studies have been few to none: exceptions are Yohannes and Matsuda (2016) and Yohannes and Matsuda (2015). This thesis intends to provide a comprehensive demand system analysis of coffee consumption in the Japanese household from a city level point of view taking into account several factors such as expenditure and price changes, demographic, and weather effects among others.

1.2 Study Objectives

There are several factors that influence the demand for coffee such as: responses to changes in its expenditure, price, demographic factors, taste and preference, and weather to name a few. In Japan, the popularity for coffee demand has risen significantly over the past several years. Some of these influences could be attributed to western consumption lifestyles, growth of promotional strategy on coffee products, expansion in the number of coffee sales outlets, and the presence of Japanese style cafes (All Japan Coffee Association, 2010). Understanding all these factors thoroughly helps to understand the consumption behavior of coffee in Japan. Therefore, this thesis attempts to analyze household coffee demand in Japan with regards to expenditure, price, demographic and weather using a large database. Results should contribute on understanding the nature of coffee demand in Japan by showing how coffee consumers allocate coffee expenditure. In doing so, the study will add to the growing body of empirical evidence which could be useful for policy evaluation and other references.

The main objectives of the thesis are as follows:

i. To determine effects of expenditure and price changes on coffee demand in the Japanese households.

ii. To assess the significance of demographic factors on coffee demand in Japan.

iii. To evaluate weather effect on coffee demand in Japan.

iv. To estimate non-alcoholic beverages demand in Japanese household.

v. To evaluate substitution between coffee categories in Japan.

We chose this study since Japan is one of the top coffee consuming nations globally. Understanding its consumption behavior is important tool to derive implications for policy. Other reasons why we chose this study are due to its reliability on household data.

The novelty of the thesis is that it is the first study, according to our knowledge, to employ an inclusive demand analysis of temperature effects on household demand of coffee beverages in Japan. Moreover, it is the first study to analyze substitution for coffee product categories in Japanese household. This study, therefore, seeks to explain by analyzing all the factors that influence coffee demand responsiveness in Japanese household.

1.3 Methodology

The data used in this thesis was attained from the Family income and Expenditure Survey of Japan (FIES), conducted by the Ministry of Internal Affairs and Communication, for two or more persons' household using monthly data.

Aggregate micro data was used to conduct this research even though micro data would have been a preferable choice; however, such data is not available in the Family and Income Expenditure Survey of Japan. Nonetheless, the use of aggregate household data enables us to analyze the impact of the important demographic and weather variables affecting coffee and other non-alcoholic beverages consumption patterns in Japan. Other constraint in the data could be the evaluation of differential effects of price on other demographic groups such as gender, age and race. Considering the changes in prices, all expenditure data were deflated using the consumer price index. SHAZAM (version 10.2) econometrics software was applied in this model. To evaluate the temperature effects, monthly data was outsourced from Japan Meteorological Agency (JMA).

The model chosen for this study is the quadratic almost ideal demand system (QUAIDS) model, which was developed from utility maximization by Banks et al. (1997). The QUAIDS model not only applies the desirable properties of Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) model but also is more versatile in modeling consumer expenditure patterns. The QUAIDS model gives rise to quadratic logarithmic engel curves, whereas in the case of AIDS, the elasticities are not dependent of expenditure level. The recent applied studies using the QUAIDS are found in Matsuda (2006). This thesis employs the linear version of QUAIDS (LA/QUAIDS) model by Matsuda (2006). We chose this specific model, LA/QUAIDS, because it has the characteristics of 'Closure Under Unit Scaling' (CUUS), even with demand shifters such as demographic variables, monthly and city dummies (Alston et al., 2001). With demand shifters, the original QUAIDS of Banks et al. (1997) does not satisfy CUUS. According to Pollack and Wales (1992), CUUS is a property that ensures that estimated economic effects are constant to the scaling of the data. In addition, Pollack and Wales (1980) stated that only demand systems consistent with CUUS should be used for empirical demand analysis.

1.4 Structure of the thesis

This thesis is divided into five chapters, in which chapter one is the introduction. Chapter two reports the demand analysis of non-alcoholic beverages in Japan. Chapter three estimates the weather effect on household demand for coffee and tea in Japan. Chapter four presents the substitution in consumer demand for coffee product categories in Japan, and lastly Chapter five reports the summary and conclusions as well as policy recommendation.

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CHAPTER 2: Demand Analysis of Non-Alcoholic Beverages in Japan

This chapter presents the estimation of non-alcoholic beverages demand in Japanese household using the linear approximate quadratic almost ideal demand system model (LA/QUAIDS). Eight expenditure shares and prices demand equations for green tea, black tea, tea beverage, coffee, coffee beverage, fruit and vegetable juice, carbonated beverage and milk are estimated for two or more households in forty-nine cities for the period January 2000 through March 2013. The expenditure elasticity results indicate that green tea (2.320), black tea (1.357), coffee (1.090) and fruit and vegetable juice (1.019) are luxury goods while tea beverage (0.836), coffee beverage (0.896), carbonated beverage (0.844) and milk (0.677) are necessities in the Japanese household. The demographic effects reveal that people under the age of 18 prefer milk (5.928) than any other beverages whereas elderly people tend to drink more green tea (24.427). Moreover, temperature effects shows it has mostly positive effect on demand for tea beverage, coffee beverage, fruit and vegetable juice, and carbonated beverage and negative effect on green tea, black tea, and coffee in most of the months. The introduction is shown in the next section, followed by data and model, results, and the conclusion.

2.1 Introduction

The global non-alcoholic beverage industry is one of the biggest in the world with market size of 531.3 billion dollars in 2013 (Euromonitor, 2014). Japan is among the main market in the non-alcoholic beverage industry with sales revenue of 31.3 billion dollars in 2013 (Japan Soft Drink Association, 2014). In the Japanese non-alcoholic beverage industry, tea beverage holds the largest market segment (with 5.4 billion liters produced in 2013) and is followed by carbonated beverage (3.6 billion liters in 2013), fluid milk (3.0 billion liters in 2013), coffee beverage (2.9 billion liters in 2013), mineral water (2.8 billion liters in 2013), fruit and vegetable juice (1.7 billion liters in 2013), and sports beverage (1.6 billion liters in 2013). Other smaller categories beverages such as lactic beverage (496.0 million liters in 2013) and soy milk (164.9 million liters in 2013) comprise the remaining share of the beverage group (Japan Soft Drink Association, 2014). In terms of largest market sales globally, Japan has the third largest demand for fruit and vegetable juice after the United States and China with net sales of 10.4 billion dollars in 2012. However, its per capita consumption is lower than many nations at 18 liters (Euromonitor, 2012). Similarly, Japan's consumption per capita for carbonated beverage is also relatively smaller at 28.6 liters in 2013 (Japan Soft Drink Association, 2014). During the same year, the United States' per capita was five times more than Japan's at 165.8 liters (Statista, 2014). Even though, demand for both tea and coffee is significant in the Japanese non-alcoholic beverage industry, its per capita consumption has remained relatively the same since the year 2000 at 1.0 liter and 3.4 liters per person respectively (Helgi Library, 2011, ICO, 2014). As for the demand of fluid milk, its per capita consumption shows it has been on a decline for the past decade from 39.0 liters in 2000 to 31.8 liters by 2010 (Ministry of Agriculture, Forestry and Fisheries of Japan). Watanabe and Suzuki (2006) confirmed this validity in their analysis of perceptions and attitudes concerning milk consumption stressing little can be done to increase the demand of milk. Moreover, Schluep Campo and Beghin (2005) pointed out that milk consumption is regular in 80% of Japanese household and by 90% of the total population, as 4 out 5 Japanese are aware of its high nutritional quality.

There haves been quite few studies that analyzes the demand for non-alcoholic beverages in different countries over the years: Kinnucan, Miao, Xiao, and Kaiser (2001), Yen, Lin, Smallwood, and Andrews (2004), Pofahl, Capps Jr, and Clauson (2005), Zheng and Kaiser (2008), and Dharmasena, Capps Jr, and Clauson (2009) to name a few have all analyzed the demand pattern of non-alcoholic beverages in the United States using annual time series data. The numbers of previous studies on demand of non-alcoholic beverages in Japan however are very few. Nonetheless, there are a number of studies that focuses mainly on milk demand. Some of the relevant studies: Watanabe, Suzuki, and Kaiser (1997) examined consumer's preferences of milk and other beverages using Japanese consumer data and Quantification theory type III. Their results indicate that middle-aged people prefer soda and alcoholic beverages to milk beverages while younger people prefer milk.

Watanabe, Suzuki, and Kaiser (1998) using a logit model analyzed the consumption of milk for nine beverages in Japan. Their results concluded that many of the consumers attribute had a major relation with the consumption of other beverages. Stroppiana, Riethmuller, and Kobayashi (1998) analyzed the consumption of milk in nine Japanese regions. Their finding indicates that structural factors such as consumer age and size of the household have an effect on the consumption of milk at regional and national level in Japan. Watanabe et al. (2006) estimated demand for milk and other dietary products using Heckman's two- step estimators of the type II Tobit model. Their result shows that higher estimation on milk utility and higher health concerns are significant determinant for milk consumption.

Most of the studies mentioned are related mainly on milk and do not concentrate on other beverages in the Japanese household. Moreover, they do not incorporate a complete demand model in addition to examining a wide range of factors and beverage varieties. This study applies a comprehensive demand model for eight expenditure shares and prices in the Japanese non-alcoholic beverages household. Since Japan is one of the biggest producing and consuming nation of non-alcoholic beverages, which could be a useful tool for beverage manufacturers as well as for policy makers.

Regarding consumption of non-alcoholic beverages, there are several factors that could influence its demand pattern. Some of these factors include expenditure, price, demographic variables, and temperature. Temperature is an important feature of consumer behavior. There have been quite few studies that analyzed temperature effects on consumer demand, to mention some: Harrison (1992), Agnew and Palutikof (1999), Parker and Tavasolli (2000), Roslow, Li, and Nicholls (2000), Murray, Di Muro, Finn, and Popkowski Leszczyc (2010), and Bahng and Kincade (2012). However, these studies do not examine the demand for non-alcoholic beverages with regards to temperature effects. Our study, using the LA/QUAIDS model, attempts to analyze the demand for non-alcoholic beverages in Japanese household. To attain the analysis of this study, we jointly estimate eight demand equations taking into account the effects of demographic and temperature by evaluating the monthly city data for green tea, black tea, tea beverage, coffee, coffee beverage, fruit and vegetable juice, carbonated beverage, and milk. In addition, to a general concern about demand of non-alcoholic beverages in Japanese household, it is a great interest to determine whether the beverages are necessity, luxury, or an inferior good. According to our knowledge, the novelty of the study is it is the first study to analyze temperature effect on non-alcoholic beverages demand in Japanese household.

The rest of the chapter is presented as the following, a discussion of the data set and model in section 2.2, followed by a discussion of the results in section 2.3 and lastly the conclusion in section 2.4.

2.2 Data and Model

Monthly aggregate pseudo panel data, which is repeated cross sectional data, is used in this study for two or more person households from January 2000 to March 2013 for 49 cities, attainted from the Family Income and Expenditure Survey (FIES) of Japan, conducted by the Ministry of Internal Affairs. Pseudo panel data, suggested by Deaton (1985), is an alternative econometric method for estimating demand models of individual behavior. One of the advantages of pseudo panel data over panel data is that it allows us to estimate models over a longer period of time. In addition it eliminates individual-level measurement error.

The use of aggregate pseudo panel data enables us to capture the impact of the important demographic and temperature variable affecting non-alcoholic beverages patterns in Japan. Considering the changes in prices, all expenditure data for green tea, black tea, tea beverage, coffee, coffee beverage, fruit and vegetable, carbonated beverage and milk were deflated using the consumer price index. To conduct the estimation process, we used the SHAZAM (version 10.2) econometrics software. A sample size of 7789 is included in this study. The iterative seemingly unrelated regression (ISUR) was used to estimate the linear system of eight equations. To ensure non-singularity of the error covariance matrix, we deleted the 8th equation for milk. We apply two types of dummy variables into the demand system: monthly dummy variables to adjust the monthly variation and city dummy variables to capture the city variation. Several demographic variables from the FIES were incorporated in the study to understand the demand patterns of non-alcoholic beverages in the Japanese households. These variables include size (number of persons per household), under (number of persons per household under the aged of 18), elders (number of persons per household over the age of 65), age (age of the head), and rent (rate of those paying rent). The study does not include variables such as gender and race since those data are not available at the FIES. To assess the temperature effects, monthly data from January 2000 to March 2013 were outsourced from Japan Meteorological Agency.

The quadratic almost ideal demand system (QUAIDS) model, which was developed from utility maximization by Banks, Blundell, and Lewbel (1997), not only holds the desirable properties of Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) model but also is more versatile in modeling consumer expenditure patterns. The QUAIDS model gives rise to quadratic logarithmic Engel curves, that is, allowing such circumstances where incremental in expenditure would change a luxury to a necessity, whereas for the AIDS model, it gives rise to Engel curves that are linear in logarithm of total expenditure. Moreover, for QUAIDS model, the expenditure elasticity depends on the level for expenditure while for the AIDS model the elasticities are not dependent of expenditure level (Banks et al., 1997). The recent applied studies on QUAIDS are presented in Matsuda (2006). For our study purpose, we employ the linear version of QUAIDS (LA/QUAIDS) model by Matsuda (2006). We selected this specific model, LA/QUAIDS, because it features the characteristics of 'Closure Under Unit Scaling' (CUUS) even with demand shifters such as demographic variables and monthly and city dummies (Alston, Chalfant, & Piggott, 2001). With demand shifters, the original QUAIDS of Banks et al. (1997) does not fulfill CUUS. According to Pollak and Wales (1992), CUUS is a property that ensures that estimated economic effects are constant to the scaling of the data. Moreover, Pollak and Wales (1980) stated that only demand systems consistent with CUUS should be used for empirical demand analysis.

Following Matsuda (2006), the LA/QUAIDS model is derived as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{P^C} + \frac{\lambda_i}{P^Z} \left(\log \frac{y}{P^C} \right)^2 \qquad i = 1,2,\ldots,n \tag{1}$$

where w_i is the expenditure share of good i, y is total expenditure within the system, p_j is the price of good j, α_i, β_i, γ_{ij}, and λ_i are parameters to be estimated.

$$\log P^C = \sum_i \overline{w}_i \log p_j \tag{2}$$

The loglinear analogue of the Laspeyres price index is shown in Equation 2. P^C is invariant to changes in units. $^-$ stands for the sample mean.

We apply index P^Z as proposed by Matsuda (2006) in Equation 3:

$$\log P^Z = \sum_{i=1}^{n} \left(w_i - \overline{w}_i\right) \log \frac{p_i}{\overline{p}_i} \tag{3}$$

where P^Z could be seen as a zero degree homogenous analogue of the Törnqvist price index analogue and is likewise invariant to changes units.

We define the estimated LA/QUAIDS model using expenditures shares and prices for the demand of green tea, black tea, tea beverage, coffee, coffee beverage, fruit and vegetable juice, carbonated beverage and milk with regards to demographic, temperature, and other dummy variables as follow:

$$w_i = \alpha_{i0} + \alpha_{i1} t + \sum_{k=1}^{6} \alpha_{i,1+k} Z_k + \sum_{m=1}^{11} \alpha_{i,7+m} D_m + \alpha_{i19} h + \sum_{r=1}^{48} \alpha_{i,19+r} M_r + \sum_{j=1}^{8} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{P^C} + \frac{\lambda_i}{P^Z} \left(\log \frac{y}{P^C} \right)^2 \quad i = 1,2,...,8 \tag{4}$$

where t indexes the time in months, z_k are demographic variables, D_m are monthly dummy variables, h is temperature, M_r are city dummy variables. The parameters consequently are expected to meet the following restrictions:

$$\sum_{i=1}^{8} \alpha_{i0} = 0 \qquad \sum_{i=1}^{8} \alpha_{ik} = 0 \qquad k = 1,2,...,67 \tag{5}$$

$$\sum_{i=1}^{8} \beta_i = 0 \tag{6}$$

$$\sum_{i=1}^{8} \lambda_i = 0 \tag{7}$$

$$\sum_{i=1}^{8} n_{ij} = 0 \quad j = 1,2,..., 8 \tag{8}$$

$$\sum_{j=1}^{8} \gamma_{ij} = 0 \quad i = 1,2,..., 8 \tag{9}$$

The ensuing demand system jointly ensures that it fulfills adding up and homogeneity. In addition, symmetry is guaranteed by the additional restriction:

$$\gamma_{ij} = \gamma_{ji} \qquad i, j = 1,2,...,8 \tag{10}$$

The expenditure, uncompensated, and compensated price elasticities can be calculated as follows:

$$\varepsilon_i = 1 + \frac{\beta_i}{w_i} + \frac{2\lambda_i}{w_i P^Z} \log \frac{y}{P^C} \qquad i = 1,2,...,8 \tag{11}$$

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_i}{w_i} - \frac{\beta_i \overline{w}_j}{w_i} - \frac{\lambda_i}{w_i P^Z}\left[2\overline{w}_j + \left(w_j - \overline{w}_j\right)\log \frac{y}{P^C}\right]\log \frac{y}{P^C} \qquad i, j = 1,2,...,8 \tag{12}$$

$$\varepsilon_{ij}^c = \varepsilon_{ij} + \varepsilon_{iw_j} \quad \text{(Slutsky equation)} \qquad i, j = 1,2,...,8 \tag{13}$$

where δ_{ij} is the Kronecker delta: $\delta_{ij} = 1$ for $i = j$; $\delta_{ij} = 0$ for $i \neq j$.

2.3 Results

Table 1.1. Descriptive statistics of variables

Variables	Mean	Std. deviation	Minimum	Maximum
Number of persons per household (z_1)	3.126	0.184	2.58	4.13
Number of persons per household under the age of 18 (z_2)	0.682	0.139	0.22	1.3
Number of persons per household over the age of 65 (z_3)	0.611	0.126	0.21	1.38
Age of the head (z_4)	54.848	2.571	47.00	64.00
Rate of those paying rent (%) (z_5)	24.204	9.354	0.0	56.8
Expenditure share of green tea (w_1)	0.100	0.059	0.01	0.638
Expenditure share of black tea (w_2)	0.018	0.013	0	0.223
Expenditure share of tea beverage (w_3)	0.098	0.036	0	0.235
Expenditure share of coffee (w_4)	0.107	0.040	0	0.358
Expenditure share of coffee beverage (w_5)	0.065	0.026	0.01	0.195
Expenditure share of fruit & vegetable juice (w_6)	0.184	0.043	0.02	0.47
Expenditure share of carbonated beverage (w_7)	0.057	0.025	0.01	0.18
Expenditure share of milk (w_8)	0.371	0.061	0.15	0.76
Price of green tea (p_1)	101.670	3.819	87.92	118.39
Price of black tea (p_2)	106.300	6.909	86.59	132.73
Price of tea beverage (p_3)	112.890	15.28	87.62	159.87
Price of coffee (p_4)	103.390	9.72	81.26	145.06
Price of coffee beverage (p_5)	109.870	9.28	87.10	138.36
Price of fruit & vegetable juice (p_6)	105.950	7.59	88.14	135.27
Price of carbonated beverage (p_7)	114.570	14.00	84.33	149.42
Price of milk (p_8)	95.693	4.77	79.73	109.34
Temperature (H)	15.324	8.34	-5.70	30.50

Table 1.1 reports the descriptive statistics of variables. The expenditure share of milk (0.371), fruit and vegetable juice (0.184) and coffee (0.107) show they have the

highest mean expenditure shares whereas black tea (0.018) and carbonated beverage (0.057) have the lowest mean expenditure shares in the household.

Table 1.2. Estimates of expenditure and price coefficients

Left-hand variable w_i	Regressor										
	$\log p_1$	$\log p_2$	$\log p_3$	$\log p_4$	$\log p_5$	$\log p_6$	$\log p_7$	$\log p_8$	$\log \frac{y}{P^C}$	$\frac{1}{P^Z}\left(\log \frac{y}{P^C}\right)^2$	R^2
Green tea	-0.127 ***	-0.014	0.008	-0.004	0.021	0.090 ***	0.022	0.006	0.134 ***	0.173 ***	0.598
	(-3.890)	(-0.812)	(0.325)	(-0.372)	(0.965)	(3.271)	(1.011)	(0.227)	(32.280)	(15.094)	
Black tea		-0.003	0.004	-0.006 *	-0.008	0.009	-0.001	0.016 *	0.006 ***	0.002	0.222
		(-0.604)	(0.618)	(-1.659)	(-1.252)	(1.103)	(-0.193)	(1.847)	(5.061)	(0.709)	
Tea beverage			-0.103 ***	-0.010	-0.037 ***	-0.046 ***	0.034 ***	0.001	-0.017 ***	-0.015 **	0.669
			(-7.990)	(-1.421)	(-3.092)	(-3.007)	(2.882)	(0.041)	(-7.383)	(-2.426)	
Coffee				0.010	0.037 **	0.017	0.028 *	0.008	0.010 ***	-0.005	0.549
				(1.150)	(2.394)	(0.860)	(1.797)	(0.385)	(3.235)	(-0.652)	
Coffee beverage					-0.019 *	-0.002	-0.027 ***	0.060 ***	-0.007 ***	-0.028 ***	0.544
					(-1.936)	(-0.146)	(-2.658)	(4.624)	(-3.393)	(-5.158)	
Fruit & vegetable juice						0.042 *	0.022	-0.160 ***	0.004	0.004	0.512
						(1.897)	(1.260)	(-7.183)	(1.241)	(0.448)	
Carbonated beverage							-0.133 ***	0.084 ***	-0.009 ***	-0.021 ***	0.614
							(-14.699)	(7.249)	(-4.964)	(-4.294)	
Milk								0.023	-0.120 ***	0.173 ***	
								(0.933)	(-29.404)	(15.090)	

The degrees of freedom of the demand system are 53,595. The corresponding critical values of the t-distribution for 1%, 5%, 10% significance levels are 2.576, 1.960, and 1.645, respectively. ***, **, and * mean that the estimate is different from zero at the 1%, 5%, and 10% significance levels, respectively. R means that the estimate is derived from adding-up restriction. Defined as the squared correlation between the observed and predicted shares, R^2 is computed for each single equation. t-values are in parentheses.

Table 1.2 reports the estimates of expenditure and price coefficients at the mean shares. The price coefficients for green tea (-0.127), tea beverage (-0.103), coffee beverage (-0.019), fruit and vegetable juice (0.042), and carbonated beverage (-0.133) are statically significant at the 1% level, whereas black tea, coffee, and milk are not significant. In the case of total expenditure, with the exception of fruit and vegetable juice, all other beverages are significant at the 1% level. As for the quadratic log-linear expenditure, green tea (0.174), tea beverage (-0.015), coffee beverage (-0.027), carbonated beverage (-0.020) and milk (0.174) are significant at the 1% level. Black tea, coffee, and fruit and vegetable juice are not significant. The estimated R^2 results were satisfactory. They ranged from 0.222 for black tea equation to 0.669 for tea beverage equation indicating the model explains well the expenditure shares and prices for the non-alcoholic beverages in the household budget.

The estimates of expenditure and uncompensated price elasticities are shown in Table 1.3. The expenditure elasticity for green tea (2.320), black tea (1.357), tea beverage (0.836), coffee (1.090), coffee beverage (0.896), fruit and vegetable juice (1.019), carbonated beverage (0.844) and milk (0.677) are all significant at the 1% level. More precisely, the expenditure elasticity for green tea, black tea, coffee and fruit and vegetable juice are elastic, while tea beverage, coffee beverage, carbonated beverage and milk are expenditure inelastic. In other words, green tea, black tea, coffee and fruit and vegetable juice are luxuries while tea beverage, coffee beverage, carbonated beverage and milk are necessities. This means that for instance a 1% increase in the non-alcoholic beverage expenditures increases demand for green tea by 2.320 % and black tea by 1.357% respectively.

As for the uncompensated own-price elasticities, all eight beverages are significant at the 1% level. With the exception of fruit and vegetable juice and milk, which are own-price inelastic, all other beverages are own-price elastic. More specifically, carbonated beverage has the most own-price elastic and fruit and vegetable juice has the most own-price inelastic. This implies that if prices for green tea, black tea, tea beverage, coffee, coffee beverage, and carbonated beverage are lowered, total expenditure will increase since to the quantity sold will augment by large percentage than the decrease in price (see Table 1.3). Whereas for fruit and vegetable juice and milk, the indication is that a fall in price of the beverages will affect a smaller percentage change in quantity demanded. Using the LA/QUAIDS model, Dharmasena et al. (2009) also found the own-price elasticity of coffee to be elastic at -1.64. Moreover, Zheng and Kaiser (2008) using the LA/AIDS model found the uncompensated price elasticity for soft drinks (carbonated beverage) and milk to be price inelastic at -0.521 and -0.301 respectively, which is consistent with our results. Using Rotterdam and Translog demand system model, both Kinnucan et al. (2001) and Yen et al. (2004) also found carbonated beverage and milk to be price inelastic.

The uncompensated cross-price elasticities show that nineteen pairs are gross substitutes. Among the beverages group, tea beverage have the most number of substitutes whereas coffee has the least number of substitute pairs. The top pair of substitute is carbonated beverage and milk. This means that, for instance, a 1% increase in the price of carbonated beverage increases demand for milk by 1.534%, while a 1% increase in the price of milk increases demand for carbonated beverage by 0.247%. In addition, this result is consistent with Watanabe et al. (1997), who also found milk to be substitute with carbonated beverage in the Japanese household.

As for complementary beverages, twenty pairs are found to be gross complement in the beverages group. Coffee and fruit and vegetable juice have the most number of pairs among the group while black tea has the least number of complementary pair.

Table 1.3. Estimates of expenditure and uncompensated price elasticities at the mean shares

	Price p_j								
Demand q_i	Expenditure y	Green tea	Black tea	Tea beverage	Coffee	Coffee beverage	Fruit & vegetable juice	Carbonated beverage	Milk
Green tea	2.320 ***	-2.795 ***	-0.203 **	0.835 ***	-0.427 ***	0.338 ***	0.601 ***	-0.019	-0.651 ***
	(56.276)	(-9.882)	(-2.448)	(6.061)	(-5.146)	(2.758)	(3.381)	(-0.173)	(-3.444)
Black tea	1.357 ***	-1.064 **	-1.344 ***	0.812 ***	-0.489 ***	-0.375	0.893 **	0.109	0.102
	(18.783)	(-2.240)	(-4.483)	(2.542)	(-2.735)	(-1.329)	(2.233)	(0.405)	(0.246)
Tea beverage	0.836 ***	1.000 ***	0.154 ***	-1.976 ***	0.016	-0.423 ***	-0.483 ***	0.673 ***	0.202
	(35.837)	(7.115)	(2.705)	(-15.585)	(0.301)	(-5.428)	(-4.207)	(9.330)	(1.523)
Coffee	1.090 ***	-0.277 ***	-0.076 **	-0.010	-1.009 ***	-0.008	0.652 ***	-0.086 **	-0.276 ***
	(39.440)	(-3.545)	(-2.574)	(-0.208)	(-18.993)	(-0.186)	(9.193)	(-2.093)	(-3.540)
Coffee beverage	0.896 ***	0.665 ***	-0.093	-0.646 ***	0.008	-1.242 ***	-0.460 ***	-0.236 **	1.108 ***
	(29.867)	(3.509)	(-1.224)	(-5.476)	(0.116)	(-8.568)	(-3.068)	(-2.440)	(7.016)
Fruit & vegetable juice	1.019 ***	0.459 ***	0.091 **	-0.277 ***	0.387 ***	-0.171 ***	-0.656 ***	-0.013	-0.840 ***
	(55.933)	(4.710)	(2.387)	(-4.490)	(9.399)	(-3.213)	(-5.771)	(-0.263)	(-9.345)
Carbonated beverage	0.844 ***	0.115	0.042	1.153 ***	-0.135 *	-0.264 **	-0.010	-3.281 ***	1.534 ***
	(27.867)	(0.610)	(0.514)	(9.317)	(-1.756)	(-2.407)	(-0.060)	(-23.466)	(9.627)
Milk	0.677 ***	-0.011	0.017	0.069 **	-0.036	0.208 ***	-0.353 ***	0.247 ***	-0.818 ***
	(61.564)	(-0.217)	(0.855)	(1.963)	(-1.592)	(7.512)	(-7.936)	(10.000)	(-12.397)

See notes to Table 1.2.

Table 1.4 reports the estimates of compensated price elasticities at the mean shares. All eight compensated own-price elasticities are significantly negative, which are consistent from theoretical perspective. As for the compensated cross-price elasticities, twenty-four pairs are found to be significantly gross substitutes. Among the beverages group, tea beverage has the most number of pair and seems to be substitute with every other beverages with the exception of coffee beverage. Carbonated beverage has the least number of pair among the group. Moreover, sixteen pairs are found to be gross complements. Coffee beverage and fruit and vegetable juice have the most pairs among the beverage group while carbonated beverage and milk have the least number of pairs. One of the complementary pairs is milk and fruit and vegetable juice. This result is consistent with the studies of Yen et al. (2004), Zheng and Kaiser (2008), and Dharmasena et al. (2009). In their study, Yen et al. (2004) found milk as a complement to juice. Table 1.3 shows coffee and milk as gross complements however Table 1.4 shows they are gross substitutes.

Table 1.4. Estimates of compensated price elasticities at the mean shares

Demand q_i	Price p_j							
	Green tea	Black tea	Tea beverage	Coffee	Coffee beverage	Fruit & Vegetable juice	Carbonated beverage	Milk
Green tea	-2.563 ***	-0.162 *	1.063 ***	-0.179 **	0.489 ***	1.028 ***	0.114	0.210
	(-9.075)	(-1.956)	(7.722)	(-2.151)	(3.988)	(5.769)	(1.059)	(1.108)
Black tea	-0.927 *	-1.320 ***	0.945 ***	-0.344 *	-0.287	1.142 ***	0.187	0.605
	(-1.956)	(-4.403)	(2.963)	(-1.922)	(-1.017)	(2.855)	(0.695)	(1.461)
Tea beverage	1.084 ***	0.169 ***	-1.894 ***	0.105 **	-0.368 ***	-0.329 ***	0.721 ***	0.512 ***
	(7.722)	(2.963)	(-14.948)	(1.980)	(-4.733)	(-2.866)	(9.996)	(3.855)
Coffee	-0.167 **	-0.056 *	0.097 **	-0.892 ***	0.063	0.852 ***	-0.024	0.128 *
	(-2.151)	(-1.922)	(1.980)	(-16.738)	(1.515)	(12.035)	(-0.579)	(1.646)
Coffee beverage	0.754 ***	-0.077	-0.558 ***	0.104	-1.184 ***	-0.296 **	-0.184 *	1.441 ***
	(3.988)	(-1.017)	(-4.733)	(1.515)	(-8.171)	(-1.970)	(-1.908)	(9.107)
Fruit & vegetable juice	0.561 ***	0.109 ***	-0.176 ***	0.496 ***	-0.105 **	-0.469 ***	0.045	-0.462 ***
	(5.769)	(2.855)	(-2.866)	(12.035)	(-1.970)	(-4.120)	(0.920)	(-5.144)
Carbonated beverage	0.200	0.057	1.236 ***	-0.045	-0.209 *	0.145	-3.233 ***	1.847 ***
	(1.059)	(0.695)	(9.996)	(-0.579)	(-1.908)	(0.920)	(-23.117)	(11.577)
Milk	0.057	0.029	0.136 ***	0.037 *	0.252 ***	-0.229 ***	0.286 ***	-0.567 ***
	(1.108)	(1.461)	(3.855)	(1.646)	(9.107)	(-5.144)	(11.577)	(-8.579)

See notes to Table 1.2.

Table 1.5 reports the estimates of monthly rates of shift and demographic effects at the mean shares. The effect of the linear time trend (t) on demand is the monthly rate of shift. Five of the eight beverages are shown to have a significant effect on quantity demanded. With the exception of black tea, coffee beverage, and fruit and vegetable juice, all other beverages are significant at the 1% level. As time goes by, demand for green tea (0.182), tea beverage (0.166), coffee (0.175), and carbonated beverage (0.146) increases while demand for milk (-0.179) decreases in the household. When the household size increases (z_1), demand is positive for coffee beverage (10.563), carbonated beverage (22.601), and milk (4.271), while it is negative for green tea (-26.647), and black tea (-20.559). When the household size is younger (z_2), demand for fruit and vegetable juice (12.752) and milk (5.928) is positive while demand for green tea (-13.115), tea beverage (-6.584), coffee (-9.630), and coffee beverage (-16.821) is negative. Intuitively, this is true; as in Japan children tend to drink milk due its many nutritional values and health benefit. This result is consistent with Watanabe et al. (1997) who found younger people, larger families, and people with calcium distress consume more milk than any other segment of the household. In addition, they mentioned that increase of consumption of milk among age group has a lot to do with breakfast habits, as people are more likely to consume milk during breakfast than any other meal. When there are more elders in the household (z_3), demand for green tea (24.427) and milk (10.438) is positive while black tea (-11.045), tea beverage (-

8.452), coffee (-23.999), coffee beverage (-17.447), and carbonated beverage (-20.530) is negative. This is true as far as Japan is concerned since elderly people tend to be more conscious on their health and diet and beverages such as green tea and milk contribute to that aspect. This finding is also consistent with Watanabe et al. (1997) findings of positive relationship between health concerns and preferences of milk demand for elderly people. When the household head is older (z_4), demand for green tea (0.807), coffee (0.840), carbonated beverage (0.582) and milk (0.407) are positive while demand for tea beverage (-0.864), coffee beverage (-1.781), and fruit and vegetable juice (-0.926) are negative. When the percentage of those paying rents increases (z_5), demand for tea beverage (0.093), coffee beverage (0.231), fruit and vegetable juice (0.166), and carbonated beverage (0.339) is positive while demand for coffee (-0.091), and milk (-0.205) is negative.

Table 1.5. Estimates of monthly rates of shift and demographic effects at the mean shares

Demand q_i	Monthly rate of shift (%/month)	Demographic variable z_k: Number of persons per household (%/person)	Number of persons under the age of 18 (%/person)	Number of persons per household over the age of 65 (%/person)	Age of the head (%/year old)	Rate of those paying rents (%)
Green tea	0.182 ***	-26.647 ***	-13.115 *	24.427 ***	0.807 *	0.085
	(2.852)	(-5.495)	(-1.941)	(3.463)	(1.756)	(1.080)
Black tea	0.176	-20.559 **	0.264	-11.045 *	0.890	0.172
	(1.273)	(-2.420)	(0.022)	(-0.893)	(1.105)	(1.242)
Tea beverage	0.166 ***	0.272	-6.584 *	-8.452 **	-0.864 ***	0.093 **
	(3.420)	(0.099)	(-1.719)	(-2.114)	(-3.317)	(2.076)
Coffee	0.175 ***	-2.071	-9.630 **	-23.999 ***	0.840 ***	-0.091 *
	(7.763)	(-0.634)	(-2.116)	(-5.052)	(2.716)	(-1.708)
Coffee beverage	-0.015	10.563 ***	-16.821 ***	-17.447 ***	-1.781 ***	0.231 ***
	(-0.281)	(2.990)	(-3.417)	(-3.392)	(-5.320)	(4.022)
Fruit & vegetable juice	0.014	-1.845	12.752 ***	-2.267	-0.926 ***	0.166 ***
	(0.499)	(-0.860)	(4.266)	(-0.726)	(-4.558)	(4.763)
Carbonated beverage	0.146 **	22.601 ***	-7.993	-20.530 ***	0.582 *	0.339 ***
	(2.548)	(6.337)	(-1.608)	(-3.953)	(1.720)	(5.837)
Milk	-0.179 ***	4.271 ***	5.928 ***	10.438 ***	0.407 ***	-0.205 ***
	(-10.414)	(3.296)	(3.282)	(5.536)	(3.317)	(-9.714)

See notes to Table 1.2. Sample standard deviations are in square brackets.

Table 1.6 shows the estimates of temperature effects at the mean shares. Temperature shows negative effects on demand of green tea and black tea in most of the months whereas coffee is negatively significant all year round. Moreover, temperature for tea beverage, coffee beverage, fruits and vegetable juice and carbonated beverage mostly show positive effects. This is true with regards to Japan as beverages such as tea beverage, coffee beverage, fruit and vegetable juice and carbonated beverage are usually served cold whereas green tea, black tea and coffee are usually served hot through vending machine. For instance, carbonated beverages such as Coca-Cola and Sprite are usually preferred during hot temperature whereas drinks such as green tea or black tea are preferable during cold temperature. As for the demand of milk, it is only significant in the month of July. One possible explanation could be milk is not usually served in the vending machine.

The highest negative temperature effects are particularly seen in the month of July, September and October on green tea, April, June, and July on black tea, June, August, and December on coffee. To give an example, demand for green tea decreases by -2.568% in September as temperature rises by 1 degree Celsius. As for positive effects is concerned, it is mostly high in July and August for both tea beverage and coffee beverage, from July to October for fruit and vegetable juice, and from September to October for carbonated beverage. For instance, as temperature rises by 1 degree Celsius, demand for tea beverage increases by 2.095% in the month of July.

With the exception of milk, temperature effect is mostly significant for all other beverages. Moreover, these effects positive and negative are higher during the summer seasons.

Table 1.6. Estimates of temperature effects at the mean shares (%/℃)

Demand q_i	January		February		March		April		May		June	
Green tea	-0.390		-0.196		0.095		-0.054		4.025	***	-1.825	**
	(-0.788)		(-0.439)		(0.200)		(-0.101)		(5.196)		(-2.000)	
Black tea	-0.938		-0.546		0.420		-2.434	**	-0.794		-3.397	***
	(-1.082)		(-0.695)		(0.504)		(-2.590)		(-0.584)		(-3.397)	
Tea beverage	0.755	***	0.704	***	1.071	***	2.369	***	0.722		1.322	**
	(2.692)		(2.772)		(3.976)		(7.800)		(1.643)		(2.556)	
Coffee	-1.496	***	-1.255	***	-1.939	***	-2.344	***	-2.499	***	-3.190	***
	(-4.493)		(-4.168)		(-6.071)		(-6.510)		(-4.789)		(-5.194)	
Coffee beverage	0.247		0.634	*	1.132	***	1.285	***	0.381		1.355	**
	(0.684)		(1.945)		(3.273)		(3.293)		(0.674)		(2.037)	
Fruit & vegetable juice	0.433	**	0.299		0.266		0.311		-0.468		1.008	**
	(1.981)		(1.512)		(1.265)		(1.315)		(-0.468)		(2.495)	
Carbonated beverage	-0.240		-0.385		0.169		0.089		-0.634		-1.112	*
	(-0.659)		(-1.169)		(0.483)		(0.226)		(-1.112)		(1.910)	
Milk	0.160		0.054		-0.127		-0.216		-0.258		0.289	
	(1.211)		(0.456)		(-0.998)		(-1.507)		(-0.258)		(1.184)	

(%/℃)

Demand q_i	July		August		September		October		November		December	
Green tea	-3.381	***	-1.377	**	-2.568	***	-3.778	***	-0.817	*	2.043	***
	(-6.130)		(-2.086)		(-4.507)		(-7.252)		(-1.707)		(4.367)	
Black tea	-1.788	*	-0.518		-1.583		-1.611	*	-0.122		0.567	
	(-1.838)		(-0.447)		(-1.586)		(-1.757)		(-0.145)		(0.691)	
Tea beverage	2.095	***	2.214	***	0.610	*	1.495	***	1.293	***	1.304	***
	(6.699)		(5.916)		(1.889)		(5.057)		(4.749)		(4.913)	
Coffee	-1.771	***	-3.215	***	-2.228	***	-2.560	***	-2.169	***	-3.020	***
	(-4.784)		(-7.232)		(-5.808)		(-7.302)		(-6.745)		(-9.583)	
Coffee beverage	1.326	***	1.456	***	0.411		1.220	***	-0.127		0.011	
	(3.297)		(3.023)		(0.990)		(3.209)		(-0.361)		(0.033)	
Fruit & vegetable juice	2.106	***	0.577	**	1.319	***	1.644	***	0.923	***	4.351	
	(8.631)		(1.974)		(5.236)		(7.129)		(4.351)		(0.384)	
Carbonated beverage	1.511	***	0.359		1.991	***	2.128	***	1.152	***	-1.606	***
	(3.721)		(0.740)		(4.748)		(5.543)		(3.258)		(-4.665)	
Milk	-0.555	***	0.140		0.217		0.082		-0.104		0.188	
	(-3.769)		(0.795)		(1.423)		(0.591)		(-0.810)		(1.504)	

See notes to Table 1.2.

2.4 Conclusion

This study using the LA/QUAIDS model analyzed the demand for non-alcoholic beverages in Japan for eight beverages group using monthly data obtained from FIES. The estimated results reveal that expenditure elasticities for green tea, black tea, coffee, and fruit and vegetable juice are elastic while tea beverage, coffee beverage, carbonated beverage, and milk are inelastic. This implies that green tea, black tea, coffee, and fruit and vegetable juice are luxuries whereas tea beverage, coffee beverage, carbonated beverage, and milk are necessities in the household. The empirical results for uncompensated own-price elasticities show that demand for green tea, black tea, tea beverage, coffee, coffee beverage, and carbonated beverage are own-price elastic while demand for fruit and vegetable juice and milk are inelastic.

The cross-price elasticities for both uncompensated and compensated show that most of the beverages are complement to each other. As for demographic effect is concerned, it is found to play a key role in the determinant of the non-alcoholic beverages consumption. The results reveal that people under the age of 18 prefer milk and fruit and vegetable juice than any other beverages, while elderly people prefer more green tea in addition to milk. This indicates that in the Japanese household demand, there is a strong association between consumer behavior and its health and dietary implication. With regards to seasonal effects, the study reveals that when temperature rises, people consume more tea beverage, coffee beverage, fruit and vegetable juice, and carbonated beverage whereas when temperature drops consumers prefer more green tea, black tea and coffee. In reality, this is true since green tea, black tea, and coffee are usually served hot and consumed at home whereas beverages such as tea beverage, coffee beverage, fruit and vegetable juice and carbonated beverage are served cold and are frequently consumed in convenience shops and through vending machines.

The findings of our study have an implication for dairy manufacturing companies. Milk, which is set to be good for health, would increase if dairy manufacturers in Japan can develop new milk products, targeting children and elderly people, based on the findings of our study.

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CHAPTER 3: Weather Effects on Household Demand for Coffee and Tea in Japan

This chapter presents a linear approximate quadratic almost ideal demand system model (LA/QUAIDS) estimation analyzing weather effects on household demand for coffee and tea in Japan. Five expenditure shares and prices demand equations for coffee and tea group: green tea, black tea, tea beverage, coffee, and coffee beverage are estimated for two or more households in forty-nine cities, for the period January 2000 through March 2012. Empirical results show that demand for green tea, black tea, and tea beverage are own-price elastic while coffee and coffee beverage are own-price inelastic. The expenditure elasticity estimates that green tea and black tea are luxuries, while tea beverage, coffee and coffee beverage are necessities in the Japanese household. In addition, temperature has a positive effect on demand for tea beverage and coffee beverage and has a negative effect on green tea, black tea and coffee throughout the year. The introduction is outlined in the next section followed by data and model, then results, and lastly the conclusion.

2.1 Introduction

Coffee is one of the most demanded agricultural commodities in the world and each day an average of 2.25 billion cups of coffee are consumed worldwide (Daviron, Ponte, 2005; ICO). Since 1970, global coffee consumption has almost doubled by 91% reaching 8.1 million tons in 2010 (ICO). Globally, the top coffee consuming nations are the industrialized economies, constituting more than 70% of the total demand (ICO). Japan is one of the industrialized nations that saw its coffee demand increase over the past few years. According to the International Coffee Organization, Japan ranks as the fourth largest coffee consuming nation in the world after the United States, Brazil, and Germany with 7.1 million bags in 2012. However, its per capita consumption at 3.4 kg per person has remained unchanged since the year 2000 (ICO).

In Japan, the largest potential coffee market is still by far the retail household market; however, the out-of home consumption market has been on a steady increase over the past few years. According to a study made by the International Coffee Organization, Japanese out-of home coffee consumption has increased from 26.9% in 2000 to 28.7% of the total percentage share in 2011. Conversely, in-home coffee consumption has decreased from 66.8% to 62.9% of the total percentage share during the same time period.

Similar to coffee, tea is also one of the major consumed beverages globally. In fact, next to water, tea is the most consumed beverage at 5.9 billion cups per day; twice the amount of coffee output (ITC). Worldwide, tea consumption has increased by 5.6% to 4 million tons in 2010 (FAO, 2011). In Japan, the major tea markets consist of green tea and black tea. The consumption pattern among the tea groups has remained reasonably unchanged for the past 30 years. Green tea, which is considered the traditional beverage in Japan, has seen its consumption decline gradually since the 1970s; from 100,000 tons to nearly to 90,000 tons in 2010. As for the demand of black tea, it makes up about 15,000-17,000 tons per year in consumption (FAO, 2012). The overall tea consumption per capita in Japan has been steady over the past couple of years totaling 1.0 kg per person (Helgi Library, 2011).

As one of the most coveted beverages in the world, both coffee and tea haves been the focus of researchers, economists and policy makers alike. There are haves been several studies that exclusively focus on the demand of coffee and tea. For coffee, these studies include those of Goddard and Akiyama (1989), Okunade (1992), Yeboah (1992), Houston et al. (2003), and Gebrehiwot and Daloonpate (2012) to name a few. With regards to tea, Nguyen and Rose (1987), Vishwasrao and Bosshardt (1996) and Weerahewa (2003) among others have estimated the price and income elasticities of tea demand in various countries using different empirical models. However, none of these studies have employed a comprehensive demand model in addition to examining a wide range of factors such as demographic on coffee and tea demand; exceptions are: Kinnucan et al. (2001), Yen et al. (2004), Pofahl et al. (2005), Zheng and Kaiser (2008), and Dharmasena et al. (2009) to name a few. These studies estimated demand of non-alcoholic beverages in the United States using annual time series data. With the exception of Dharmasena et al. (2009), these studies do not consider coffee and tea as varieties but instead as a combined category. Moreover, there studies focus mainly on advertising expenditure. Our study incorporates a comprehensive demand system method, taking into account demographic and weather effects by focusing exclusively on coffee and tea. One of the major reason we chose Japan as our study area is because Japan is a top coffee and tea consuming nation globally. Understanding its consumption behavior, therefore, is imperative for marketing strategy in the beverage industry as well as for policy implementation. Other reason is the data set (for two or more persons` household) on Japanese household is reliable and informative.

There are several factors that influence the demand of coffee and tea consumption: expenditure, price, demographic variables (such as family size, age of the household), taste, preferences and weather. Weather is an important determinant factor of demand for consumer spending. Prior studies pointed out that weather variables such as temperature and sunshine have a significant effect on consumer behavior. Parker and Tavasolli (2000) stated that consumers adapt to changes in the environment by transforming their purchasing pattern to both optimal stimulation and to maintain their psychological homeostasis. Over the years, there have been several studies about weather effects on consumption in particular product categories. In his study, Harrison (1992) stated that when temperature falls, demand for ice cream decreases while demand for oatmeal porridge increases. Likewise, Agnew and Palutikof (1999), and Roslow et al. (2000) mentioned that people tend to demand more food and drinks in the summer and more clothing and footwear during winter. Understanding the role weather has on consumers good, therefore, is crucial for any industry. Particularly for the coffee and tea industry understanding the part weather plays in the consumption pattern would reveal significance information for beverage manufacturers, suppliers as well as retailers. One of the primary causes for the steady weather changes worldwide is global warming.

Global warming, which is the rise of gradual temperature, is a major worldwide issue these days. Previous studies with regard to temperature rise in Japan showed that global warming has in fact impacted Japan, evidenced by its annual temperature rise of 1 degree Celsius over the last century (Japan Meteorological Agency, 2005). Some of these studies include those of Fujibe (1995), Kato (1996), Yue and Hashino (2003), and Fujibe et al. (2007). According to our knowledge, there hasn't been a study that analyzes temperature effect with regards to coffee and tea in Japan. This study, therefore, is the first to our knowledge to employ an analysis of weather effects on the demand of coffee and tea beverage in Japanese households. In doing so, the study will add to the growing body of empirical evidence which could be useful for policy evaluation and other references. The study will shed some light on the demand of coffee and tea in Japan. In addition, to a general concern about household coffee and tea consumption behavior in Japan, it is of great interest to ascertain whether coffee and tea are a necessity, luxury or an inferior good. To achieve the research goals, we jointly estimated five demand equations taking into account the effects of demographic and weather by evaluating the monthly city data of Japanese consumption for green tea, black tea, tea beverage, coffee and coffee beverage.

The rest of the chapter is drawn as the following; a discussion of the data set and model is shown on section 3.2, followed by a discussion of the results in section 3.3 and lastly the conclusion in section 3.4.

3.2 Data and Model

The data used in this study is monthly aggregate pseudo panel data for two or more person households from January 2000 to March 2012 for 49 major cities, attainted from the Family Income and Expenditure Survey (FIES) of Japan, conducted by the Ministry of Internal Affairs. According to the Ministry of Justice, the number of registered foreigners in Japan is estimated at 2,078,508 (2011), which accounts for 1.6% of the population, which is much smaller than in other developed countries. For example, foreigners make up 13% in the United States, 13% in the United Kingdom, and 8.8% in Germany.

The use of aggregate pseudo panel data enables us to capture the impact of the important demographic and weather variables affecting coffee and tea consumption patterns in Japan. Considering the changes in prices, all expenditure data for green tea, black tea, tea beverage, coffee and coffee beverage were deflated using the consumer price index. To conduct the estimation process, SHAZAM (version 10.2) econometrics software was used. A sample of 7152 observations is included in this study. Beforehand a test for heteroskedasticity introduced by Engle (1982) is conducted equation by equation. Under the null hypothesis of homoskedasticity the test statistic can be compared with chi squared distribution with 1 degree of freedom.

With test statistics of 0.309–16.165, the null hypothesis of homoskedasticity cannot be rejected at the 1 % significance level for 4 of the 5 equations. The linear system of 5 equations was estimated using the iterative seemingly unrelated regressions (ISUR). The 5th equation for coffee beverage was deleted to ensure non-singularity of the error covariance matrix. Our study applies two types of dummy variables into the demand system: monthly dummy variables to adjust the monthly variation and city dummy variables to capture the city variation. In order to clearly understand the demand patterns of coffee and tea in the Japanese households, our study incorporates several demographic variables from the FIES. These variables include adults (number of adults per household), elders (number of persons per household aged 65 and above), earners (number of earners per household), age (age of the head) and owners (home ownership rate). Home ownership was chosen as an explanatory variable because home is often one of the major properties of Japanese family. Other demographic variables such as under (number of persons per household under the age of 18), unemployment (number of unemployed persons per household), and rent (rate of those paying rent), were excluded from the study since they were found to be insignificant. Limitation of the study could be the data set does not allow us to evaluate effects on the demand of other demographic factors such as gender and race; however, these data are not available at the FIES. To evaluate the temperature effects, monthly data from January 2000 to March 2012 were outsourced from Japan Meteorological Agency.

The quadratic almost ideal demand system (QUAIDS) model, which was developed from utility maximization by Banks et al. (1997), not only applies the desirable properties of Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) model but also is more versatile in modeling consumer expenditure patterns. The QUAIDS model gives rise to quadratic logarithmic engel curves, whereas in the case of AIDS, the elasticities are not dependent of expenditure level. The recent applied studies using the QUAIDS are shown in Matsuda (2006). For our study, we employ the linear version of QUAIDS (LA/QUAIDS) model by Matsuda (2006). We chose this specific model, LA/QUAIDS, because it has the characteristics of 'Closure Under Unit Scaling' (CUUS), even with demand shifters such as demographic variables, monthly and city dummies (Alston et al., 2001). With demand shifters, the original QUAIDS of Banks et al. (1997) does not satisfy CUUS. According to Pollak and Wales (1992), CUUS is a property that ensures that estimated economic effects are constant to the scaling of the data. In addition, Pollak and Wales (1980) stated that only demand systems consistent with CUUS should be used for empirical demand analysis.

Following Matsuda (2006), the LA/QUAIDS model can be defined as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{P^C} + \frac{\lambda_i}{P^Z} \left[\log \frac{y}{P^C} \right]^2, i = 1, \ldots, n \qquad (1)$$

where w_i is the expenditure share of good *i*, p_i is the price of good *i*, *y* is total expenditure within the system, α_i, β_i, and γ_{ij} are parameters to be estimated; λ_i is homogenous of degree zero in price.

$$\log P^C = \sum_i \overline{w}_i \log p_i \qquad (2)$$

Eq. 2 implies the loglinear analogue of the Laspeyres price index, P^C, is invariant to changes in units; $\overline{w}_i = E(w_i y)/E(y)$ which is the sample mean of w_i.

In Eq. 3, we apply index P^Z as proposed by Matsuda (2006):

$$\log P^Z = \sum_{i=1}^{n} (w_i - \overline{w}_i) \log \frac{p_i}{\overline{p}_i} \qquad (3)$$

where P^Z could be viewed as a zero degree homogenous analogue of the Törnqvist price index analogue and is also invariant to changes units.

The estimated LA/QUAIDS model using expenditures shares and prices for the demand of green tea, black tea, tea beverage, coffee and coffee beverage with regards to weather, demographic and other dummy variables is defined as the following:

$$w_i = \alpha_{i0} + \alpha_{i1} t + \sum_{k=1}^{5} \alpha_{1,1+k} z_k + \sum_{m=1}^{11} \alpha_{1,6+m} + D_m \sum_{l=1}^{3} \alpha_{i,17+l} h_l + \sum_{l=1}^{3} \sum_{m=1}^{11} \theta_{ilm} h_l D_m + \sum_{r=1}^{48} \alpha_{1,20+r} M_r$$
$$+ \sum_{j=1}^{5} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{P^C} + \frac{\lambda_i}{P^Z} \left(\log \frac{y}{P^C} \right)^2$$

$$i = 1, 2, \ldots, n. \qquad (4)$$

where w_i and p_i represent the expenditure shares and prices, respectively, for green tea, black tea, tea beverage, coffee, and coffee beverage per household, y is the total expenditure, z_k are demographic variables, t indexes the time in months, D_m are the monthly dummy variables, h_l are weather variables, M_r are city dummy variables and α_i, β_i, γ_{ij}, and θ_{ilm} are unknown, parameters. The parameters, therefore, are assumed to meet the following restrictions:

$$\sum_{i=1}^{n} \alpha_i = 0, \tag{5}$$

$$\sum_{i=1}^{n} \beta_i = 0, \tag{6}$$

$$\sum_{i=1}^{n} \lambda_i = 0, \tag{7}$$

$$\sum_{i=1}^{n} \gamma_{ij} = 0, \quad j = 1,2,...,n, \tag{8}$$

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \quad i = 1,2,...,n, \tag{9}$$

The resulting demand system jointly ensures that it fulfills adding-up and homogeneity. In addition, symmetry is guaranteed by the additional restriction:

$$\gamma_{ij} = \gamma_{ji}, \quad i, j = 1,2,...,n. \tag{10}$$

The expenditure, uncompensated and compensated price elasticities calculated by the linear approximate formulas differ from the nonlinear formulas and can be defined as the following:

$$\varepsilon_i = 1 + \frac{\beta_i}{w_i} + \frac{2\lambda_i}{w_i P^Z} \log \frac{y}{P^C}, \quad i = 1,2,.., n, \tag{11}$$

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_i}{w_i} - \frac{\beta_i}{w_i} - \overline{w}_j - \frac{\lambda_i}{w_i P^Z}\left[2\overline{w}_j + \left(w_j - \overline{w}_j\right)\log\frac{y}{P^C}\right]\log\frac{y}{P^C} \tag{12}$$

$$i, j = 1,2,\ldots n$$

$$\varepsilon_{ij}^{c} = \varepsilon_{ij} + \varepsilon_{iw_j} \quad \text{(Slutsky equation)} \tag{13}$$

$$i,\ j = 1,2,\ldots,\ n$$

Where ε denotes the uncompensated price elasticity measure, δ_{ij} is Kronecker delta;

$\delta_{ij} = 1$ for $i = j$; $\delta_{ij} = 0$ for $i \neq j$

3.3 Results

Table 2.1. Wald test statistics for coefficients

Regressor	Degrees of freedom	Wald	p-value
Squared log real expenditure	4	263.878	[0.000]
Homothetic preferences	4	1364.096	[0.000]
Linear time trend	4	86.097	[0.000]
Adult	4	22.487	[0.000]
Number of persons per household aged 65 and above	4	34.416	[0.000]
Number of earners per household	4	12.417	[0.015]
Age of the head	4	35.731	[0.000]
Home ownership rate (%)	4	20.321	[0.000]
Temperature	4	83.142	[0.000]
Monthly dummies	44	306.000	[0.000]
Temperature × Monthly dummies	44	215.419	[0.000]
City dummies	192	14994.527	[0.000]

H_0: All coefficients of the regressor(s) are zeroes. H_1: Not all coefficients of the regressor(s) are zeroes.

Table 2.1 shows Wald test statistics for coefficients of regressors other than log prices and log expenditure. The linear approximate AIDS (Deaton and Muellbauer, 1980) is rejected by the LA/QUAIDS. Homothetic preferences and omission of the other regressors are also rejected.

Table 2.2. Descriptive statistics of variables

Variables	Mean	Std. deviation	Minimum	Maximum
Number of persons per household (z_1)	3.133	0.185	2.58	4.13
Number of persons per household aged 65 and above (z_2)	0.604	0.123	0.21	1.38
Number of earners per household (z_3)	1.351	0.166	0.54	0.54
Age of the head (z_4)	54.646	2.481	47.0	64.0
Homeownership rate (z_5)	73.827	9.821	40.3	100.0
Expenditure share of green tea (w_1)	0.255	0.119	0.016	0.935
Expenditure share of black tea (w_2)	0.045	0.031	0	0.498
Expenditure share of tea beverage (w_3)	0.254	0.089	0	0.566
Expenditure share of coffee (w_4)	0.276	0.091	0	0.712
Expenditure share of coffee beverage (w_5)	0.170	0.072	0.018	0.505
Price of green tea (P_1)	101.70	3.891	87.92	118.39
Price of black tea (P_2)	106.89	6.782	89.49	132.73
Price of tea beverage (P_3)	114.29	15.036	91.01	159.87
Price of coffee (P_4)	107.57	9.533	84.85	145.06
Price of coffee beverage (P_5)	110.78	8.996	92.08	138.36

The descriptive statistics of variables are presented in Table 2.2. The expenditure share for green tea (0.255), tea beverage (0.254) and coffee (0.276) show that they have the highest mean expenditure shares, whereas, black tea (0.045) and coffee beverage (0.170) have the lowest mean.

Table 2.3. Estimates of expenditure and price coefficients

Left-hand variable w_i	Regressor							
	$\log p_1$	$\log p_2$	$\log p_3$	$\log p_4$	$\log p_5$	$\log \frac{y}{P^C}$	$\frac{1}{P^Z}\left(\log \frac{y}{P^C}\right)^2$	R^2
Green tea	-0.208 ***	-0.004	0.245 ***	-0.021	-0.012	0.168 ***	0.131 ***	0.669
	(-4.187)	(-0.233)	(8.821)	(-1.199)	(-0.389)	(34.310)	(15.160)	
Black tea		-0.012	0.039 ***	-0.003	-0.020	0.002	-0.005	0.228
		(-1.006)	(3.164)	(-0.334)	(-1.576)	(1.095)	(-1.326)	
Tea beverage			-0.199 ***	-0.102 ***	0.016	-0.087 ***	-0.055 ***	0.684
			(-7.442)	(-6.904)	(0.902)	(-24.340)	(-8.775)	
Coffee				0.117	0.009	-0.038 ***	-0.022 ***	0.569
				(7.590) ***	(0.730)	(-8.985)	(-2.968)	
Coffee beverages					-0.002	-0.045 ***	-0.049 ***	
					(-0.013)	(-14.382)	(-8.827)	

The degrees of freedom of the demand system are 28,217. The corresponding critical values of the t-distribution for 1%, 5%, 10% significance levels are 2.576, 1.960, and 1.645 respectively. ***, **, and * mean that the estimate is different from zero at the 1%, 5%, and 10% significance levels, respectively. R means that the estimate is derived from adding-up restriction. Defined as the squared correlation between the observed and predicted shares, R^2 is computed for each single equation. t-values are in parentheses.

The estimates of expenditure and price coefficients at the mean shares are reported in Table 2.3. The price coefficients for green tea (-0.208), tea beverage (-0.199) and coffee (0.117) are statistically significant at the 1% level. As for the total expenditure, other than black tea, green tea (0.168), tea beverage (-0.087), coffee (-0.038) and coffee beverage (-0.045) are all significant at the 1% level. Similar to total expenditure, the quadratic log-linear expenditure with the exception of black tea is significant for green tea (0.131), tea beverage (-0.055), coffee (-0.022) and coffee beverage (-0.049). The sign of price, total expenditure and quadratic log-linear expenditure elasticities are all consistent with the theory, and their magnitudes are within expecting range. The estimated R^2 values range from 0.228 for black tea equation to 0.684 for tea beverage equation. The high R^2 values indicate that the model explains well the expenditure shares and prices of coffee and tea in the household budget.

Table 2.4. Estimates of expenditure and uncompensated price elasticities at the mean shares

Demand q_i	Price p_j					
	Expenditure y	Green tea	Black tea	Tea beverage	Coffee	Coffee beverage
Green tea	1.659 ***	-1.984 ***	-0.105	1.055 ***	-0.040 ***	-0.002
	(86.373)	(-10.157)	(-0.263)	(9.590)	(-0.633)	(-0.013)
Black tea	1.047 ***	-1.272 ***	-0.047	0.169 ***	-0.003	-0.105
	(24.403)	(-4.736)	(-0.653)	(3.484)	(-0.106)	(-1.413)
Tea beverage	0.659 ***	-1.698 ***	0.845 ***	0.794 ***	-0.333 ***	0.164
	(46.943)	(-16.115)	(3.122)	(7.296)	(-6.222)	(1.535)
Coffee	0.861 ***	-0.539 ***	-0.069	-0.306 ***	-0.264 ***	0.124 *
	(55.474)	(-9.741)	(-0.412)	(-5.292)	(-3.872)	(1.799)
Coffee beverage	0.733 ***	-0.915 ***	-0.445	0.123 *	0.055	-0.159
	(39.582)	(-6.113)	(-1.604)	(1.710)	(1.280)	(-1.318)

See notes to Table 2.3.

Table 2.4 reports the estimates of expenditure and uncompensated price elasticities evaluated at the sample means of expenditure shares. Our model is a conditional demand system. Expenditure is just for coffee and tea. Expenditure elasticity for green tea (1.659), black tea (1.047), tea beverage (0.659), coffee (0.861), and coffee beverage (0.733) are all significant at the 1% level. To be more precise, the expenditure elasticities for green tea and black tea are elastic while tea beverage, coffee, and coffee beverages are expenditure inelastic. That is, green tea and black tea are luxuries while tea beverage, coffee and coffee beverage are necessities. This means that, for example, the demand for green tea increases by 1.659% when the expenditure increases by 1%. With regards to coffee expenditure elasticity, we found our estimates to be consistent with previous studies. Goddard and Akiyama (1989), Okunade (1992) and Yeboah (1992) all found demand for coffee to be price inelastic. Dharmasena et al. (2009) using the LA/QUAIDS model also found expenditure price elasticity for coffee to be inelastic (0.462). As for the uncompensated own-price elasticities, all five beverages are significant at the 1% level. Green tea, black tea and tea beverage are own-price elastic while coffee and coffee beverage are own-price inelastic. In particular, green tea has the most own-price elastic demand and coffee has the most own-price inelastic. It means that if prices for green tea, black tea and tea beverage are reduced, total expenditure will increase since the quantity sold will increase by a larger percentage than the decrease in price. For coffee and coffee beverage, the indication is that fall in price of the beverages will cause a smaller percentage change in the quantity demanded. The cross-price elasticities of green tea in response to tea beverage (0.794), black tea in response to tea beverage (0.845), tea beverage in response to green tea (1.055), black tea (0.169), and coffee beverage (0.123), coffee beverage in response to coffee (0.124) are all significantly positive. These six pairs are gross substitutes. On the other hand, the cross-price elasticities of green tea in response to coffee (-0.264), tea beverage in response to coffee (-0.306), and coffee in response to tea beverage (-0.333) are significantly negative. These three pairs are gross complements.

Table 2.5. Estimates of compensated price elasticities at the mean shares

	Price p_j				
Demand q_i	Green tea	Black tea	Tea beverage	Coffee	Coffee beverage
Green tea	-1.561 ***	0.162	1.223 ***	0.179 ***	0.185
	(-8.008)	(0.404)	(11.147)	(2.830)	(1.021)
Black tea	0.029	-1.225 ***	0.199 ***	0.036	-0.071
	(0.404)	(-4.559)	(4.101)	(1.302)	(-0.963)
Tea beverage	1.215 ***	1.111 ***	-1.531 ***	-0.115 **	0.350 ***
	(11.147)	(4.101)	(-14.518)	(-2.151)	(3.274)
Coffee	0.194 ***	0.220	-0.125 **	-0.302 ***	0.326 ***
	(2.830)	(1.302)	(-2.151)	(-5.416)	(4.717)
Coffee beverage	0.123	-0.267	0.234 ***	0.201 ***	-0.790 ***
	(1.021)	(-0.963)	(3.274)	(4.717)	(-5.283)

See notes to Table 2.3.

Estimates of compensated elasticities at the mean shares are presented in Table 2.5. All five compensated own-price elasticities are significantly negative, which are theoretically consistent. As for compensated cross-price elasticities, ten pairs are found to be significantly substitutes. Green tea is substitute with tea beverage (1.223) and coffee (0.179), black tea is substitute with tea beverage (0.199), tea beverage is substitute with green tea (1.215), black tea (1.111), and coffee beverage (0.350), coffee is substitute with green tea (0.194) and coffee beverage (0.326), and coffee beverage is substitute with tea beverage (0.234) and coffee (0.201). Among the group, tea beverage seems to be substitute for all beverages with the exception of black tea. The top pair of substitutes is green tea and tea beverage. This means that, for example, a 1% increase in the price of green tea increases demand for tea beverage by 1.223%, while a 1% increase in the price of tea beverage increases demand for green tea by 1.215%. Further, the pairs tea beverage and coffee (-0.115), and coffee and tea beverage (-0.125) are complement to each other. Table 2.4 shows coffee is gross complement to green tea but Table 2.5 shows they are substitute to each other. It seems reasonable that substitutes are dominant.

Table 2.6. Estimates of monthly rates of shift and demographic effects at the mean shares

		Demographic variable z_k				
Demand q_i	Monthly rate of shift (%/month)	Number of persons per household (%/person) Adult	Number of persons per household over the age of 65 (%/person)	Number of earners per household (%/person)	Age of the head (%/year old)	Home ownership rate (%/%)
Green tea	-0.239 ***	-12.111 ***	31.023 ***	-7.511 **	0.757 **	0.077
	(-6.714)	(-3.978)	(5.529)	(-2.038)	(2.294)	(1.348)
Black tea	-0.062	-4.258	-12.917	-18.733 **	0.389	0.003
	(-0.83)	(-0.626)	(-1.030)	(-2.273)	(0.53)	(0.022)
Tea beverage	0.096 ***	3.786 **	-3.446	2.160	-0.666 ***	-0.056
	(3.733)	(1.701)	(-0.840)	(0.801)	(-2.761)	(-1.340)
Coffee	-0.044 ***	2.182	-19.382 ***	3.779	0.820 ***	0.116 **
	(-3.039)	(0.887)	(-4.273)	(1.267)	(3.076)	(2.519)
Coffee beverage	0.304 ***	10.136 ***	-6.549	6.928 **	-1.578 ***	-0.222 ***
	(9.11)	(3.449)	(-1.208)	(1.946)	(-4.954)	(-4.019)

See notes to Table 2.3. Sample standard deviations are in square brackets.

The monthly rate of shift and demographic effects at the mean shares are estimated in Table 2.6. The monthly rate of shift is the effect of the linear time trend (t) on demand. Four of the five beverages show a significant effect on quantity demanded. With the exception of black tea, green tea (-0.239), tea beverage (0.096), coffee (-0.044) and coffee beverage (0.304) are all significant at the 1% level. Tea beverage and coffee beverage show an upward trend while green tea and coffee show a downward trend. This means that, as time goes by, demand for tea beverage and coffee beverage increases while demand for green tea and coffee decreases in the household. When there are more adults in the household (z_1), the effect on demand for tea beverage (3.786) and coffee beverage (10.136) is positive, while it is negative on green tea (-12.111). When there are more elders in the household (z_2), demand for green tea (31.023) is positive and negative for coffee (-19.382). Green tea's high demand among elders can be attributed to Japan's long traditional drinking habits as well as its health benefits. Intuitively, coffee is more popular drink among adults than elders, which explains the positive demand of coffee beverage. When there are more earners in the household (z_3), demand for coffee beverage (6.928) is positive whereas for green tea (-7.511) and black tea (-18.733) is negative. When the household head is older (z_4), demand for green tea (0.757) and coffee (0.820) is positive and negative for tea beverage (-0.666) and coffee beverage (-1.578). When the owner has his own house (z_5), demand for coffee (0.116) is positive while it is negative for coffee beverage (-0.222). This is relatively true because in Japan wealthy families who own their house prefer to drink coffee at home. These results seem reasonable from the viewpoint of real life experience.

Table 2.7. Estimates of temperature effects at the mean shares (%/°C)

Demand q_i	January	February	March	April	May	June
Green tea	-1.193 ***	-1.435 ***	-1.156 **	-1.775 ***	-0.849	-2.356 ***
	(-2.888)	(-3.657)	(-2.595)	(-3.327)	(-1.261)	(-3.153)
Black tea	-0.622	-0.316	-0.591	-1.319	-2.540 *	-5.360 ***
	(-0.673)	(-0.360)	(-0.593)	(-1.105)	(-1.686)	(-3.207)
Tea beverage	1.601 ***	1.589 ***	1.975 ***	2.487 ***	1.763 ***	3.531 ***
	(5.298)	(5.541)	(6.055)	(6.379)	(3.581)	(6.462)
Coffee	-1.763 ***	-1.662 ***	-2.359 ***	-2.544 ***	-3.070 ***	-3.758 ***
	(-5.288)	(-5.253)	(-6.563)	(-5.913)	(-5.644)	(-6.219)
Coffee beverage	2.430 ***	2.565 ***	2.774 ***	3.435 ***	4.306 ***	5.799 ***
	(6.089)	(6.768)	(6.447)	(6.664)	(6.615)	(8.035)

(%/°C)

Demand q_i	July	August	September	October	November	December
Green tea	-1.946 **	-1.598 *	-3.559 ***	-3.755 ***	-1.246 ***	-0.736 **
	(-2.458)	(-1.714)	(-5.101)	(-6.691)	(-2.821)	(-1.757)
Black tea	-3.673 **	-4.724 **	-3.093 **	-1.922	-0.471	-2.205 **
	(-2.073)	(-2.266)	(-1.984)	(-1.529)	(-0.476)	(-2.356)
Tea beverage	3.265 ***	4.235 ***	2.883 ***	3.730 ***	2.170 ***	1.941 ***
	(5.642)	(6.216)	(5.656)	(9.094)	(6.705)	(6.341)
Coffee	-4.268 ***	-6.614 ***	-2.787 ***	-2.005 ***	-2.223 ***	-2.000 ***
	(-6.671)	(-8.779)	(-4.951)	(-4.425)	(-6.233)	(-5.909)
Coffee beverage	5.956 ***	8.075 ***	6.392 ***	3.839 ***	2.365 ***	2.042 ***
	(7.789)	(8.970)	(9.494)	(7.077)	(5.543)	(5.049)

See notes to Table 2.3.

Temperature effects in each month are reported in Table 2.7. In every month, temperature has negative effects on demand for green tea, black tea and coffee, and positive effects on tea beverage and coffee beverage. It is probably, as far as Japan is concerned, because green tea, black tea, and coffee are usually served hot and because tea beverage and coffee beverage are mostly served cold through vending machines. The negative temperature effects are especially high in September and October on green tea, from June through September on black tea, and from May through August on coffee. This means that, for example, demand for green tea decreases by -3.755% in October as temperature rises by 1 degree Celsius. The positive temperature effects are particularly high from June through October on tea beverage and from May through September on coffee beverage. This means that, for example, as temperature rises by 1 degree Celsius, demand for coffee beverage increases by 8.075% in August. Temperature effects on all five beverages are significant in almost every month and these effects, both positive and negative, seem especially high in hot seasons.

3.4 Conclusion

This study, applying the LA/QUAIDS model, analyzed the weather effects on household demand for five groups of coffee and tea consumption in Japan using monthly data obtained from the FIES. The empirical results shows that the estimated expenditure elasticities for green tea and black tea are elastic, whereas tea beverage, coffee and coffee beverage are expenditure inelastic. The implication is that green tea and black tea are luxuries products, whereas tea beverage, coffee and coffee beverage are necessities in the household. The estimated uncompensated own-price elasticities reveal that green tea has the most own-price elastic demand and coffee has the most own-price inelastic. As for the compensated cross-price elasticity, the result shows that most of the beverages are complement to each other. Moreover, demographic characteristics is found to be important determinants of Japanese household for coffee and tea consumption. The result clearly shows that green tea is preferred by the elderly, most probably due to its long tradition and health benefits, while adults tend to consume more tea beverage and coffee beverage, which are drinks that are accessible in convenience shops and through vending machines in Japan.

Evidence of the effect of household weather characteristics on coffee and tea consumption in Japan has implications for policy. Global warming, which is the gradual rise of temperature, has a significant impact on household demand for coffee and tea in Japan throughout the year. Our study reveals that as temperature rises, consumers drink more tea beverage and coffee beverage, whereas when the temperature drops, consumers prefer green tea, black tea and coffee. Consequently, our findings have significant implications for beverage marketing strategy. Any marketing policy adopted by beverage producers and distributors should consider the important information detailed in this study as it reveals Japanese household consumption pattern of coffee and tea during seasonal changes. For example, during warmer seasons, beverage producers can put more emphasis on supplying tea beverage and coffee beverage in conveniences shops and through vending machines. During colder seasons, producers can shift their supply to green tea, black tea, and coffee drinks.

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CHAPTER 4: Substitution in Consumer Demand for Coffee Product Categories in Japan

This chapter estimates the substitution in consumer demand for coffee product categories in Japan using the linear approximate quadratic almost ideal demand system model (LA/QUAIDS). Three expenditure shares and demand equations for coffee beans and powder (beans/powder), canned and bottled coffee (canned/bottled) and coffee drunk at coffee shops (coffee shops) are estimated for two or more person households in forty-nine cities for the period January 2000 through February 2015. The expenditure elasticity estimates indicate that coffee shops (1.384) are luxury goods while beans/powder (0.902) and canned/bottled coffee (0.670) are necessities in the Japanese household. The demographic effects show that persons over the age of 65 (14.456) and people who earn more (9.230) consume coffee at coffee shops. Moreover, seasonal effects show demand for canned and bottled coffee as mostly positive while it is mostly negative for coffee drunk at coffee shops in most of the months. The findings of this study indicate that coffee product categories in the Japanese market are substitutes for one another. The introduction is outlined in the next section, followed by data and model, results, and finally the conclusion.

4.1 Introduction

Coffee is one of the most demanded agricultural commodities in the world, with a worldwide market share of $84.5 billion (Euromonitor, 2014). The global coffee consumption has been increasing steadily over the past 4 years at an average annual growth rate of 2.4%, with consumption estimated at 149.8 million bags in 2014 (ICO, 2015b). Japan is among the top coffee-consuming nation globally currently fourth behind the United States, Brazil, and Germany (ICO, 2015a). Coffee demand in Japan grew substantially in the 1960s and in the 1970s by double-digit rate; however, as the market became matured and saturated yearly growth rate dropped to 4.4% in the 1980s and went on to fall to 2.4 % and 0.6% in 1990s and 2000s respectively (Agra-net, 2015). In 2014, Japan's coffee consumption was estimated to be 7.49 million kg bags (Statista, 2015). Japan's per capita coffee consumption has remained steady at

3.5 kg (ICO, 2015a). Moreover, in terms of coffee retail price, Japan ranks higher than most of the importing nations, with approximately 5 US $/kg from 1990 to 2010; As comparison, within the same period of time, coffee retail price for the United States was around 1.5 US $/kg (ICO, 2011).

In the Japanese coffee beverage industry, instant coffee have continuously dominated the total market sales; canned and bottled coffee, which are widely available in vending machine, are the main segments of the overall beverage market (Smil and Kobayashi, 2012). Canned coffee, invented in Japan, provides hot or cold coffee in a can. Since its invention in 1969, demand roused by 40% from the overall non-instant coffee market (Thurston, Morris, & Steiman, 2013).

Coffee beverage/Instant coffee hold the largest segment with 2.12 billion liters followed by canned coffee with 661.6 million liters, coffee containing milk beverage with 147.9 million liters, and coffee containing soft drinks with 21.3 million liters for the year 2013 (Japan Soft Drink Association, 2014). As for the number of coffee shops in Japan, according to Thurston, Morris, & Steiman (2013), it has declined by 50% since 1982 mainly due to the emergence of fashionable self-service cafes or fast-food restaurant services, in which consumers order and take their coffee beverages across the counter. Moreover, international coffee chains such as Starbucks, Doutor and Tully's, to name a few, brought a serious competition for the largest domestic suppliers of fresh coffee such as Ueshima, Art Coffee, and Key Coffee (Smil and Kobayashi, 2012). Total revenue for coffee shops in Japan was estimated to be worth $2.9 billion in 2013 (Nikkei Sangyo Shimbun, 2014). Recently, demand for convenience store coffee, $1 cup of coffee, has become a popular beverage trend in Japan; Convenience store coffee, which has a price equivalent to canned coffee, has spread all over Japan and has impacted not only sales for canned coffee but for coffee shops as well (Family Income Expenditure Survey, 2015). From the start of sales in 2012, the total amount of sales at conveniences store coffee has increased by 500 million cups in less than a year (Kunifuji et al., 2014).

According to a study conducted by All Japan Coffee Association (2015), Japanese coffee consumption per week has risen steadily over the past decade. In 2002, 6.49 cups were consumed at-home and 4.55 cups were consumed out-of-home. By 2014, at-home consumption increased to 7.04 cups. Conversely, out-of-home consumption, which includes office/schools, coffee shops, restaurants and others decreased to 4.03 cups during the same year.

Over the years, several studies have analyzed the demand for coffee in different countries. To mention some: Goddard and Akiyama (1989), Okunade (1992), Yeboah (1992), Sellen and Goddard (1997), Houston, Santilla, and Marlowe (2003) and Gebrehiwot and Daloonpate (2012) have all analyzed the income and price elasticities using various demand models for coffee products and varieties. However, only few of these studies have analyzed substitution among various coffee product categories. In addition, these studies used different estimation techniques and data sets.

With regards to coffee demand, there are several dynamics that influence its consumption pattern. To name some: income and expenditure, price, demographic factors, taste, and weather. In Japan, there are numerous factors that contributed to the rise and popularity such as: influence from western consumption habits, increase in marketing strategy as well as research and development on coffee products, the continuous expansion for coffee sales outlets, and the presence of typical Japanese coffee shops (All Japan Coffee Association, 2010).

As a popular demand commodity in the Japanese market, understanding the substitution pattern among coffee product categories is significant for coffee beverage manufacturers. However, according to our knowledge, no preceding study exist that examines quantitatively the substitution relationship between coffee product categories in Japan. In this paper, we investigate the substitution pattern among three coffee brands/products: coffee beans and powder (beans/powder), canned and bottled coffee (canned/bottled), and coffee drunk at coffee shops (coffee shops). Coffee beans and powder (beans/powder) can be explained as ground coffee packaged in a large bag type and bag-type dripper presented with a disposable filter. They are usually consumed at home. Canned and bottled coffee (canned/bottled) is a ready-to-drink roasted coffee beverages packaged in plastic bottles and canned as hot or cold beverages. They are usually consumed from vending machine or at convenience store. As for coffee drunk at coffee shops, these are also roasted coffee served as hot or cold beverages at coffee shops. These coffees may differ from the other coffee products by quality and origin.

We incorporate expenditure and prices for the three coffee product categories in a comprehensive demand system model taking into account the effects of demographic and temperature by evaluating the monthly data by city.

The following hypotheses are verified: Are the three coffee product categories substitutes or complements? Does temperature play a significant role on coffee demand in Japan? How does coffee consumption affect demographic group in Japan? How sensitive is coffee demand to expenditure and price changes?

Since Japan is one of the top coffee consuming nations globally, the findings of this study will be crucial for beverage manufacturing companies. Implications of the coffee market of substitute relations of product categories are discussed. Additionally, it is of a great interest to ascertain whether these coffee product categories chosen are a necessity, luxury, or an inferior good.

The rest of the paper is drawn accordingly. Section 2 discusses data set and model, section 3 presents the results discussion and section 4 presents the conclusion.

4.2 Data and Model

For this study, we apply monthly aggregate pseudo panel data, which is repeated cross-sectional data, for two or more person households from January 2000 to February 2015 for 49 cities, attainted from the Family Income and Expenditure Survey (FIES) of Japan, conducted by the Ministry of Internal Affairs (2015). Pseudo panel data, proposed by Deaton, is an alternative econometric method for estimating demand models of individual behavior; Pseudo panel data has advantage over panel data in that it allows estimating models over a longer period of time. Moreover, it rejects individual-level measurement error (Deaton, 1985).

Using general consumer price index for all 49 cities average in Japan, all expenditure data for beans/powder, canned/bottled, and coffee shops were deflated with consideration of changes in prices. SHAZAM (version 10.2) econometrics software was used to conduct the estimation process. A sample of 8915 observations for two or more person households is used in this study. The iterative seemingly unrelated regression (ISUR) was used to estimate the linear system of the three coffee product demand equations. To ensure non-singularity of the error covariance matrix, we deleted the equation for coffee shops. We can retrieve the parameters of the omitted budget share equations by using the property of adding-up. We apply two types of dummy (1/0) variables into the demand system: monthly dummy variables to adjust the monthly variation and city dummy variables to capture the city variation. Several demographic variables from the FIES were incorporated in the study to understand demand patterns of the coffee product categories in the Japanese households. These variables include size (number of persons per household), elders (number of persons per household over the age of 65), earners (number of earners per household), age (age of the head), and rent (household percentage paying rent). Multicollinearity analysis was tested among the variables by calculating the variance inflation factors (VIF); the VIF are 1.031-3.635 (<<10) indicating no multicollinearity among the variables. The limitation of the study could be that psychometric analysis, which is an important feature for demand analysis, was not used. To estimate temperature effects, monthly data from January 2000 to February 2015 were outsourced from Japan Meteorological Agency (JMA).

The quadratic almost ideal demand system (QUAIDS) model, which was originated from utility maximization by Banks, Blundell, and Lewbel (1997), not only holds the desirable properties of Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) model but also is more versatile in modeling consumer expenditure patterns. The QUAIDS model gives rise to quadratic logarithmic engel curves that is allowing such circumstances where incremental in expenditure would change a luxury to a necessity, whereas for the AIDS model, it gives rise to engel curves that are linear in logarithm of total expenditure. For the QUAIDS model, the expenditure elasticity is contingent on the level of expenditure while for the AIDS model the elasticities are not dependent of expenditure level (Banks et al., 1997). The recent applied studies on QUAIDS can be found in Matsuda (2006). For this study, we employ the linear version of QUAIDS (LA/QUAIDS) model by Matsuda (2006). We designated this specific model, LA/QUAIDS, because it features the characteristics of 'Closure Under Unit Scaling' (CUUS) even with demand shifters such as demographic variables and monthly and city dummies (Alston, Chalfant, and Piggott, 2001). With demand shifters, the original QUAIDS of Banks et al. (1997) does not fulfill CUUS. CUUS is a property that ensures that estimated economic effects are constant to the scaling of the data (Pollack and Wales, 1992). Furthermore, Pollack and Wales (1980) stated that only demand systems consistent with CUUS should be used for empirical demand analysis.

Following Matsuda (2006), we can derive the LA/QUAIDS model as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{P^C} + \frac{\lambda_i}{P^Z} \left(\log \frac{y}{P^C} \right)^2 \qquad i = 1,2,\ldots,n \tag{1}$$

where w_i is the expenditure share of good i, y is total expenditure within the system, p_j is the price of good j, α_i, β_i, γ_{ij}, and λ_i are parameters to be estimated.

$$\log P^C = \sum_i \overline{w}_i \log p_j \tag{2}$$

The loglinear analogue of the Laspeyres price index can be shown in Equation 2. P^C is invariant to changes in units. $\overline{}$ stands for the sample mean.
We employ index P^Z as proposed by Matsuda (2006) in Equation 3:

$$\log P^Z = \sum_{i=1}^{n} \left(w_i - \overline{w}_i \right) \log \frac{p_i}{\overline{p}_i} \tag{3}$$

where P^Z could be seen as a zero degree homogenous analogue of the Törnqvist price index analogue and is equally invariant to changes units.

We posited the estimated LA/QUAIDS model using expenditures shares and prices for the demand of beans/powder, canned/bottled, and coffee shops with regards to demographic, temperature, and other dummy variables as follow:

$$w_i = \alpha_{i0} + \alpha_{i1} t + \sum_{k=1}^{5} \alpha_{1,1+k} z_k + \sum_{m=1}^{11} \alpha_{1,6+m} D_m + \alpha_{i,18} h + \sum_{r=1}^{48} \alpha_{1,18+r} M_r + \sum_{j=1}^{3} \gamma_{ij} \log p_j + \beta_i \log \frac{y}{P^C} + \frac{\lambda_i}{P^Z} \left(\log \frac{y}{P^C} \right)^2 \qquad i = 1,2,3 \tag{4}$$

where t indexes the time in months, z_k are demographic variables, D_m are monthly dummy variables, h is temperature, M_r are city dummy variables. The parameters consequently are expected to meet the following restrictions:

$$\sum_{i=1}^{3} \alpha_{i0} = 0 \qquad \sum_{i=1}^{3} \alpha_{ik} = 0 \qquad k = 1,2,\ldots,66 \tag{5}$$

$$\sum_{i=1}^{3}\beta_i = 0 \tag{6}$$

$$\sum_{i=1}^{3}\lambda_i = 0 \tag{7}$$

$$\sum_{i=1}^{3} n_{ij} = 0 \quad j = 1,2,3 \tag{8}$$

$$\sum_{j=1}^{3}\gamma_{ij} = 0 \quad i = 1,2,3 \tag{9}$$

The ensuing demand system jointly ensures that it fulfills adding up and homogeneity. In addition, symmetry is guaranteed by the additional restriction:

$$\gamma_{ij} = \gamma_{ji} \qquad i,j = 1,2,3 \tag{10}$$

The expenditure, uncompensated, and compensated price elasticities can be defined as follows:

$$\varepsilon_i = 1 + \frac{\beta_i}{w_i} + \frac{2\lambda_i}{w_i P^Z}\log\frac{y}{P^C} \qquad i = 1,2,3 \tag{11}$$

$$\varepsilon_{ij} = -\partial_{ij} + \frac{\gamma_i}{w_i} + \frac{\beta_i \bar{w}_j}{w_i} - \frac{\lambda_i}{w_i P^Z}\left[2\bar{w}_j + \left(w_j - \bar{w}_j\right)\log\frac{y}{P^C}\right]\log\frac{y}{P^C}\ i,j = 1,2,3 \tag{12}$$

$$\varepsilon_{ij}^{C} = \varepsilon_{ij} + \varepsilon_{iwj}\text{(Slutsky equation)} \qquad i,j = 1,2,3 \tag{13}$$

where δ_{ij} is the Kronecker delta: $\delta_{ij} = 1$ for $i = j$; $\delta_{ij} = 0$ for $i \neq j$

4.3 Results

Table 3.1. Wald test statistics for coefficients

Regressor	Degrees of freedom	Wald	p-value
Squared log real expenditure	2	67.725	[0.000]
Homothetic preferences	2	813.867	[0.000]
Linear time trend	2	461.548	[0.000]
Number of persons per household	2	93.437	[0.000]
Number of persons per household over the age of 65	2	8.205	[0.017]
Number of earners per household	2	8.838	[0.012]
Age of the head	2	33.678	[0.000]
Rate of those paying rent	2	6.287	[0.043]
Temperature	2	195.380	[0.000]
Monthly dummies	22	1875.666	[0.000]
Temperature × Monthly dummies	22	606.008	[0.000]
City dummies	96	3206.116	[0.000]

H_0: All coefficients of the regressor(s) are zeroes. H_1: Not all coefficients of the regressor(s) are zeroes.

Table 3.1 reports Wald test statistics for coefficients of regressors other than log prices and log expenditure. The linear approximate AIDS (Deaton and Muellbauer, 1980) is rejected by the LA/QUAIDS. Homothetic preferences and omission of the other regressors are also rejected.

Table 3.2. Descriptive statistics of variables

Variables	Mean	Std. deviation	Minimum	Maximum
Number of persons per household (z_1)	3.1169	0.18384	2.58	4.13
Number of persons per household over the age of 65 (z_2)	0.628	0.134	0.21	1.38
Number of earners per household (z_3)	1.345	0.164	0.54	2.15
Age of the head (z_4)	55.202	2.706	47.0	64.2
Rate of those paying rent (z_5)	23.405	9.402	0.0	56.8
Expenditure share of beans/powder (w_1)	0.410	0.118	0	0.934
Expenditure share of canned/bottled (w_2)	0.261	0.103	0	1.000
Expenditure share of coffee shops (w_3)	0.329	0.122	0	0.950
Price of beans/powder (P_1)	109.85	49.410	1.00	915.00
Price of canned/bottled (P_2)	107.68	7.662	54.00	133.11
Price of coffee shops (P_3)	99.26	3.408	18.30	123.98

The descriptive statistics is shown on Table 3.2. The expenditure share for beans/powder (0.410) and coffee shops (0.329) have the highest mean expenditure whereas canned/bottled (0.261) have the lowest mean among the coffee product categories group.

Table 3.3. Estimates of expenditure and price coefficients

Left-hand variable w_i	Regressor					
	$\log p_1$	$\log p_2$	$\log p_3$	$\log \frac{y}{P^C}$	$\frac{1}{P^Z}\left(\log \frac{y}{P^C}\right)^2$	R^2
Beans/Powder	-0.010 **	-0.037 *	0.047 ***	-0.040 ***	-0.031 ***	0.463
	(-2.023)	(-1.767)	(2.239)	(-8.291)	(-7.610)	
Canned/Bottled		0.004	0.023	-0.086 ***	-0.002	0.587
		(0.254)	(1.416)	(-23.198)	(-0.572)	
Coffee shops			-0.062 ***	0.126 ***	0.032 ***	
			(-3.885)	(24.861)	(7.651)	

The degrees of freedom of the demand system are 17,611. The corresponding critical values of the t-distribution for 1%, 5%, 10% significance levels are 2.576 , 1.960, and 1.645 respectively. ***, **, and * mean that the estimate is different from zero at the 1%, 5%, and 10% significance levels, respectively. R means that the estimate is derived from adding-up restriction. Defined as the squared correlation between the observed and predicted shares, R^2 is computed for each single

The estimates of expenditure and price coefficients at the mean shares are reported in Table 3.3. The price coefficients for beans/powder (-0.010) and coffee shops (-

0.062) are statistically significant at the 1% level, whereas canned/bottled is not significant among the coffee group. The total expenditure for all three coffee products: beans/powder (-0.040), canned/bottled (-0.086) and coffee shops (0.126) are significant at the 1% level, indicating a significant influence of prices on the budget shares. Moreover, the quadratic log-linear expenditure for beans/powder (-0.031) and coffee shops (0.032) are significant at the 1% level. The sign of price and expenditure are consistent with the theory and their magnitudes were within expected range. The R^2 indicates the results are satisfactory.

Table 3.4. Estimates of expenditure and uncompensated price elasticities at the mean shares

Demand q_i	Expenditure y	Price p_j Beans/Powder	Canned/Bottled	Coffee shops
Beans/Powder	0.902 ***	-0.985 ***	0.032 **	-0.044 ***
	(76.535)	(-88.067)	(2.385)	(-3.056)
Canned/Bottled	0.670 ***	-0.040 ***	-0.907 ***	-0.024
	(47.347)	(-4.008)	(-15.475)	(-0.511)
Coffee shops	1.384 ***	0.123 ***	0.205 ***	-1.316 ***
	(89.605)	(8.642)	(3.510)	(-26.430)

See notes to Table 3.3.

Table 3.4 shows the estimates of expenditure and uncompensated price elasticities. Our model in this study is a conditional demand system. Expenditure is just for coffee product categories. The expenditure price elasticity for beans/powder (0.902), canned/bottled (0.670), and coffee shops (1.384) are all significant at the 1% level. The positive expenditure elasticities indicate that the coffee product categories under consideration are normal goods. More precisely, the expenditure elasticity for coffee shops are elastic, while expenditure for beans/powder and canned/bottled are expenditure inelastic. This implies that coffee shops are luxuries good while beans/powder and canned/bottled are necessities. For example, the demand for coffee shops increases by 1.384% when expenditure increases by 1%. These results are consistent with two previous studies on coffee demand in Japan. Yohannes and Matsuda (2016), analyzed weather effect on household demand for coffee and tea in

Japan, and Yohannes and Matsuda (2015), analyzed demand for non-alcoholic beverages in Japan. Both studies using the LA/QUAIDS model found coffee (beans/powder) and coffee beverage (canned/bottled) to be necessity goods.

The uncompensated own-price elasticity show that demand for beans/powder (-0.985), canned/bottled (-0.907), and coffee shops (-1.316) are all significant at the 1% level. All own-price elasticities for the coffee product items show negative signs, which is consistent with consumer demand theory. Negative own-price elasticity indicates that an increase in the price of the coffee product items results in a decrease in demand for the same group. Coffee shops are own-price elastic while beans/powder and canned/bottled are own-price inelastic. Coffee shops' own-price elasticity of 1.316 suggests that when the price of coffee shops increases by 1%, demand for coffee shops will reduce by 1.316%. The high own-price elasticity demand for coffee shops is perhaps due to the quality of coffee products served at coffee shops, such as premium organic coffee, coffee roasted by types or blends, since coffee shops is regarded as luxuries product item in Japan. The own-price elasticity of beans/powder and canned/bottled are close to unity. The result suggests that Japanese consumers are more responsive to coffee shops price than to the price of beans/powder or canned/bottled. Our findings are consistent with previous studies with regards to coffee expenditure of beans/powder and canned/bottled elasticities. In their studies, Goddard and Akiyama (1989), Okunade (1992) and Yeboah (1992) found demand for coffee to be price inelastic. Dharmasena et al. (2009), applying the LA/QUAIDS model for non-alcoholic beverages in the United States, also found coffee to be price inelastic (0.462). In addition, Yohannes and Matsuda (2016) found beans/powder (coffee) and canned/bottled (coffee beverage) to be price inelastic at (-0.302) and (-0.790) respectively.

Regarding uncompensated cross-price elasticities, all coffee product categories are inelastic. This implies that there is a weak response of one coffee product item to changes in the price of other coffee products. This outcome is anticipated since there is less substitutability between coffee product groups; substitutability occurs within coffee product groups. Three pairs are found to be substitutes: beans/powder with canned/bottled (0.032), coffee shops with beans/powder (0.123), and coffee shops with canned/bottled (0.205). These three pairs are gross substitutes since they show positive elasticities. As for complementary goods is concerned, the two pairs: beans/powder with coffee shops (-0.044) and canned/bottled with beans/powder (-0.040) show negative elasticities implying gross complementarity among these beverage items. For the first pair, beans/powder with coffee shops, as the price of coffee shops decrease demand for beans/powder increases. For the second pair, canned/bottled with beans/powder, as the price of beans/powder decreases demand for canned/bottled increases. However, the cross-price elasticities for both pairs are just slight.

Table 3.5. Estimates of compensated price elasticities at the mean shares

	Price p_j		
Demand q_i	Beans/Powder	Canned/Bottled	Coffee shops
Beans/Powder	-0.614 ***	0.307 ***	0.523 ***
	(-50.663)	(21.254)	(33.235)
Canned/Bottled	0.195 ***	-0.732 ***	0.338 ***
	(21.254)	(-12.552)	(7.337)
Coffee shops	0.419 ***	0.425 ***	-0.861 ***
	(33.235)	(7.337)	(-17.629)

See notes to Table 3.3.

Table 3.5 shows the estimates of compensated price elasticities at the mean shares. The compensated price elasticity measures the strength of the substitution effects that affect demand for the coffee product categories under consideration. The absolute values for the compensated price elasticities are normally smaller than the uncompensated price elasticities. All three compensated own-price elasticities are significantly negative, which is theoretical consistent. This means that a change in the price of any coffee product items will result in more than proportionate change in quantity demanded of the coffee product category. Based on the compensated cross-price elasticities, all coffee product categories are substitutes for one another. The result is not surprising, however, it is consistent with the reality of coffee consumption in Japan. Among these beverages group, the top pair of substitutes are beans/powder with coffee shops (0.523). This means that a 1% increase in the price of beans/powder increases demand for coffee shops by 52.3%. Yohannes and Matsuda (2016) also found beans/powder (coffee) and canned/bottled (coffee beverage) as substitutes for one another. Table 3.4 shows beans/powder to be both complementary with both coffee shops and canned/bottled but Table 3.5 shows they are substitutes for one another. It seems reasonable that substitutes are more dominant.

Table 3.6. Estimates of monthly rates of shift and demographic effects at the mean shares

		Demographic variable z_k				
Demand q_i	Monthly rate of shift (%/month)	Number of persons per household (%/person)	Number of persons per household over the age of 65 (%/person)	Number of earners per household (%/person)	Age of the head (%/year old)	Rate of those paying rent (%/%)
Beans/Powder	-0.043 ***	10.061 ***	-6.942 *	-3.598	1.279 ***	-0.057
	(-6.770)	(4.793)	(-1.789)	(-1.454)	(5.701)	(-1.371)
Canned/Bottled	0.239 ***	16.305 ***	-7.283	-5.960 **	-0.764 ***	0.122 **
	(21.355)	(6.455)	(-1.559)	(-2.002)	(-2.828)	(2.424)
Coffee shops	-0.137 ***	-25.522 ***	14.456 ***	9.230 ***	-0.990 ***	-0.025
	(-12.944)	(-9.268)	(2.840)	(2.844)	(-3.364)	(-0.464)

See notes to Table 3.3. Sample standard deviations are in square brackets.

The estimates of the monthly rate of shift and demographic effects at the mean shares are reported in Table 3.6. The monthly rate of shift is the effect of the linear time trend (t) on demand. All three of the coffee product categories show significant effect on quantity demanded. As time goes by, demand for beans/powder (-0.043) and coffee shops (-0.137) decreases while demand for canned/bottled (0.239) increase. When the household size ($z1$) increases demand for beans/powder (10.061) and canned/bottled (16.305) is positive while demand for coffee shops (-25.522) is negative. When there are more elders in the household ($z2$), demand for coffee shops (14.456) increases while demand for beans/powder (-6.942) decreases. We can speculate that people over the age of 65 may prefer drinking their coffee at coffee shops since coffee shops are places for leisure gathering. In Japan, coffee shops are mostly popular in Nagasaki, Kobe, and Yokohama, as all three cities are known to have international trade port. When there are more earners in the household ($z3$), demand is positive for coffee shops (9.230) while it is negative for canned/bottled coffee (-5.960). This is also true as far as Japan is concerned since people who earn more will tend to drink outside of their home such as at coffee shops. When the household head is older (*z*4), demand for beans/powder (1.279) is positive while demand for canned/bottled (-0.764) and coffee shops (-0.990) are negative.

Table 3.7. Estimates of temperature effects at the mean shares (%/℃)

Demand q_i	January		February		March		April		May		June	
Beans/Powder	-1.116	***	0.510	***	0.538	***	0.389	***	0.492	***	0.118	
	(-3.833)		(10.165)		(8.741)		(6.891)		(6.823)		(1.379)	
Canned/Bottled	-0.179		0.527	***	0.572	***	0.696	***	0.780	***	1.226	***
	(-0.509)		(8.468)		(7.572)		(9.972)		(8.863)		(11.778)	
Coffee shops	1.536	***	-1.055	***	-1.127	***	-1.039	***	-1.235	***	-1.122	***
	(4.020)		(-15.829)		(-13.821)		(-13.862)		(-12.965)		(-9.957)	

(%/℃)

Demand q_i	July		August		September		October		November		December	
Beans/Powder	0.038		-0.138		-0.320	***	-0.232	***	-0.551	***	0.204	***
	(0.388)		(-1.282)		(-3.218)		(-2.612)		(-8.777)		(4.472)	
Canned/Bottled	1.332	***	1.785	***	1.984	***	1.808	***	1.201	***	0.635	***
	(11.123)		(13.728)		(16.485)		(16.788)		(15.573)		(11.215)	
Coffee shops	-1.106	***	-1.247	***	-1.177	***	-1.147	***	-0.266	***	-0.760	***
	(-8.514)		(-8.834)		(-9.013)		(-9.820)		(-3.207)		(-12.497)	

See notes to Table 3.3.

The estimates of temperature effects at the mean shares are shown in Table 3.7. For beans/powder, temperature shows positive signs from the month of February to July and negative signs from August to November. For canned/bottled, with the exception of January, temperature is positive in every month. In contrast, for coffee shops, with the exception of January, temperature shows negative signs in each month. As far as Japan is concerned, this is perhaps because beans/powder is usually consumed as a hot beverage. The positive temperature effect for canned/bottled is mostly high in July and September. Studies by Yohannes and Matsuda (2016) and Yohannes and Matsuda (2015), found temperature to have a positive effect on demand for beans/powder (coffee), which is consistent with this study. The negative temperature effects for coffee shops is high in May and August but is relatively even during the season. This means that, for example, as temperature rises by 1 degree Celsius in the month of May, demand for coffee shops decreases by -1.235 %. This is perhaps because coffee is usually served as a hot beverage at coffee shops in Japan.

4.4 Conclusion

This study applying the LA/QUAIDS model analyzed substitution among three coffee product categories in Japan using monthly data obtained from FIES. The empirical results reveal that expenditure elasticities for coffee shops are elastic while demand for beans/powder and canned/bottled are inelastic. The implication is that coffee shops are luxuries good, while beans/powder and canned/bottled are necessities. The uncompensated own-price elasticities show that coffee shops are own-price elastic whereas beans/powder and canned/bottled are own-price inelastic. The uncompensated cross-price elasticity shows it is mostly significant for all coffee product categories. As for the compensated cross-price elasticity, it reveals that all coffee product categories: beans/powder, canned/bottled and coffee shops are substitutes for one another, which is consistent with reality of coffee demand in Japan. Demographic effects are found to play a significant role in the Japanese coffee consumption. As household size increases, consumers prefer to drink beans/powder and canned/bottled. As for elderly and people who earn more, the results indicate that they prefer to drink at coffee shops. This is true since coffee shops are known as a leisure place. Seasonal effects also play an important role on the responsiveness of coffee consumption in Japan. The findings suggest that when temperature rises people consume more of canned/bottled beverages, whereas when temperature drops consumers prefer to drink at coffee shops. This result makes sense since canned/bottled beverages are usually served as a cold beverage through vending machine in Japan whereas for coffee shops, it is usually served as hot beverage.

The findings of our study carry a useful implication. We find substitution among the three coffee products, which implicates competition among suppliers of coffee products. Such competition will help the growth of coffee consumption in Japan.

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Chapter 5: Summary and Conclusions

5.1 Summary

This thesis using a comprehensive demand system analysis method estimated the consumption behavior of coffee in the Japanese household from a city level by taking into account expenditure, price, demographic, weather and other variables. The previous chapters presented various studies with regards to coffee demand in Japan. Chapter 1 presented the introduction. In chapter 2, we analyzed the demand for eight non-alcoholic beverage items in Japan. In chapter 3, we examined the weather effects on household demand for coffee and tea in Japanese household for five beverage items, and in chapter 4, we estimated the substitution of consumer demand for three coffee product categories.

This study used monthly aggregate pseudo panel data for two or more person households for 49 major cities in Japan attained from FIES. To conduct temperature effects, monthly weather data was outsourced from Japan Meteorological Agency (JMA). Based on these studies result, several analysis were drawn:

First, for non-alcoholic beverages, the estimated results revealed that expenditure for green tea, black tea, coffee, and fruit and vegetable juice were found to be elastic while for tea beverage, coffee beverage, carbonated beverage, and milk it was found to be inelastic. The implication is that green tea, black tea, coffee, and fruit and vegetable juice are luxuries whereas tea beverage, coffee beverage, carbonated beverage, and milk are necessities in the household.

The own-price elasticity show that demand for green tea, black tea, tea beverage, coffee, coffee beverage, and carbonated beverage are own-price elastic while demand for fruit and vegetable juice and milk are inelastic. As for the cross-price elasticities for both uncompensated and compensated show that most of the beverages are complementary for one another.

Second, the demographic effect was found to play a critical role in the determinant of the non-alcoholic beverages consumption in Japan. The result shows that people under the age of 18 prefer milk and fruit and vegetable juice than any other beverages whereas elderly prefer green tea in addition to milk. The results indicate a strong correlation between consumer behavior and health against its dietary implication in the Japanese household. As for seasonal effects is concerned, the study reveals that when temperature rises by 1 degree Celsius, consumers drink more tea beverage, coffee beverage, fruit and vegetable juice, and carbonated beverage whereas when temperature drops by 1 degree Celsius, consumers prefer more green tea, black tea, and coffee. The results are true in reality since green tea, black tea, and coffee are usually served as a hot beverage and they are usually consumed at home whereas beverages such as tea beverage, coffee beverage, fruit and vegetable juice and carbonated beverage are served cold and are often drunk in convenience shops and through vending machines. Our study has an implication for dairy manufacturing companies in Japan. As milk is set to be good for health, dairy manufacturers can target children and elderly people by producing new milk products to engage consumers interest.

Third, with regards to the study of weather effects on household demand for coffee and tea in Japanese household is concerned, several conclusions were drawn: The result shows that expenditure elasticities for green tea and black tea are elastic, implying luxury goods, whereas for tea beverage, coffee and coffee beverage are inelastic, implying a necessity good. The own-price elasticities reveals that green tea has the most own-price elastic demand and coffee has the most own-price inelastic. The cross-price elasticities show that most of the beverages are complementary.

As for the demographic effects is concerned, the result shows that green tea is a preferred beverage among elderly, while adults prefer more tea beverage and coffee beverage. In reality, the outcomes make sense since green tea is usually consumed for its health benefits and tea beverage and coffee beverage are drinks accessible through vending machine.

As far as policy implication is concerned, global warming, which is the gradual rise of temperature has a significant impact on household demand for coffee in Japan throughout the year. The result reveals that when temperature rises by 1 degree Celsius consumers drink more green tea, black tea, and coffee whereas when temperature drops by 1 degree Celsius consumers drink more tea beverage and coffee beverage. Consequently, our results have implications for beverage marketing strategy. For instance, during warmer climate, beverage producers can stress the supply of tea beverage and coffee beverage in conveniences shops and through vending machine. Whereas during colder climate, producers can concentrate their attention on supplying green tea, black tea and coffee drinks.

Fourth, as for the study of substitution in consumer demand for coffee product categories in Japan is concerned, the estimate result reveals that expenditure elasticities for coffee shops is elastic implying a luxury good, while demand for beans/powder and canned/bottled are inelastic indicating a necessity good. The uncompensated own-price elasticities reveal that coffee shops are own-price elastic whereas beans/powder and canned/bottled are own-price inelastic. As for the compensated cross-price elasticity for the study reveals that all coffee categories are substitutes for one another.

With regards to demographic effect, they are found to play a key role in the Japanese coffee consumption. Elderly and people who earn more tend to consume coffee at coffee shops, which is true in reality. Temperature effects also play a significant role on the responsiveness of coffee consumption in Japan. The result reveals that when temperature rises by 1 degree Celsius, people consume more canned/bottled beverages, whereas when temperature drops by 1 degree Celsius, consumers favor to drink coffee at coffee shops. As for implication is concerned, our study revealed that all coffee categories are substitutes for one another. This implicates competition among suppliers of coffee products, which will help the growth of coffee consumption in Japan.

5.2 Conclusions

In conclusion, we can say that all the factors that we assumed could play a role on the consumer behavior in the Japanese household such as expenditure, price, demographic factors, taste and preference, and weather have in fact played a significant role on coffee demand in the Japanese household. In the case of non-alcoholic beverages, the results showed that young people prefer consuming milk and fruit and vegetable juice than any other beverages whereas elderly people consumed green tea and milk. This shows a correlation between consumption and healthy drinks since green tea and milk are known for their health benefits. The seasonal results shows that when its hot, consumers prefer to drink tea beverages, coffee beverages, fruit and vegetable juice and carbonated beverages whereas when its cold season, consumers prefer green tea, black tea, and coffee. This has an implication for dairy manufacturing companies to produce new milk products, targeting children and elderly people, based on the findings of our study.

In the study for weather effect on household demand for coffee and tea, it was found that global warming, which is the gradual rise of temperature, plays a significant role on demand for coffee and tea in Japanese household throughout the year. Similar to the non-alcoholic beverages, the findings for coffee and tea household demand shows that during hot seasons consumer prefer colder drinks such as tea beverage and coffee beverage, whereas when during colder seasons consumer prefer hot drinks such as green tea, black tea, and coffee. The implication is for beverage manufactures to supply colder drinks in summer seasons and hot beverages during winter seasons. As for substitution among coffee product categories, it shows that beans/powder, canned/bottled and coffee shops are all substitute for one another. This implicates competition among suppliers of coffee product categories. Such type of competition will help the growth of coffee demand in Japan.

Appendix 1.A.

Table 1.A. Wald test statistics for coefficients

Regressor	Degrees of freedom	Wald	p-value
Squared log real expenditure	7	287.066	[0.000]
Homothetic preferences	7	1509.243	[0.000]
Linear time trend	7	160.225	[0.000]
Number of persons per household	7	82.008	[0.000]
Number of persons per household under the age of 18	7	46.045	[0.000]
Number of persons per household over the age of 65	7	80.983	[0.000]
Age of the head	7	70.299	[0.007]
Rent	7	134.768	[0.000]
Temperature	7	145.029	[0.000]
Monthly dummies	77	781.384	[0.000]
Temperature × Monthly dummies	77	418.120	[0.000]
City dummies	336	22937.461	[0.000]

H_0: All coefficients of the regressor(s) are zeroes. H_1: Not all coefficients of the regressor(s) are zeroes.

Appendix 2.A.

Table 2.A. Estimates of city effects at the mean shares

Demand q_i	Sapporo		Aomori		Morioka		Sendai		Akita		Yamagata		Fukushima		Mito	
Green tea	-25.820	***	-66.548	***	-36.087	***	-17.038	***	-1.179		-15.844	***	-24.316	***	-11.768	***
	(-7.240)		(-15.833)		(-8.613)		(-4.219)		(-0.288)		(-3.760)		(-5.914)		(-2.936)	
Black tea	-34.212	***	-84.459	***	-65.927	***	-26.218	***	-46.860	***	-41.362	***	-61.904	***	-39.684	***
	(-5.459)		(-11.460)		(-8.974)		(-3.703)		(-6.535)		(-5.598)		(-8.589)		(-5.649)	
Tea beverage	7.822	***	-15.331	***	-11.766	***	-13.111	***	-4.661	**	-12.117	***	4.792	**	4.273	*
	(3.865)		(-6.435)		(-4.954)		(-5.728)		(-2.010)		(-5.073)		(2.056)		(1.881)	
Coffee	-4.507	*	-8.363	**	9.101	***	3.690		0.109		-7.225	**	-2.388		-5.896	**
	(-1.880)		(-2.955)		(3.226)		(1.357)		(0.039)		(-2.547)		(-0.862)		(-2.184)	
Coffee beverage	29.980	***	39.149	***	2.546		-18.733	***	-0.776		-1.738		-2.698		-5.864	**
	(11.476)		(12.768)		(0.833)		(-6.359)		(-0.260)		(-0.565)		(-0.900)		(-2.007)	
Fruit & vegetable juice	13.950	***	52.906	***	13.627	***	9.144	***	14.586	***	8.854	***	14.187	***	10.055	***
	(8.837)		(28.447)		(7.350)		(5.117)		(8.060)		(4.748)		(7.799)		(5.671)	
Carbonated beverage	20.453	***	38.008	***	-9.601	***	-12.144	***	5.711	*	4.501		0.941		-16.852	***
	(7.782)		(12.289)		(-3.114)		(-4.086)		(1.898)		(1.451)		(0.311)		(-5.715)	
Milk	-7.500	***	-10.465	***	7.670	***	8.897	***	-4.229	***	6.766	***	2.225	**	4.284	***
	(-7.863)		(-9.312)		(6.847)		(8.240)		(-3.867)		(6.004)		(2.024)		(3.998)	

Demand q_i	Utsunomia	Maebashi	Saitama	Chiba	Yokohama	Niigata	Toyama	Kanazawa
Green tea	-15.413 ***	3.507	-11.074 ***	-0.600	-7.279 *	-11.228 ***	-44.079 ***	-29.577 ***
	(-3.816)	(0.856)	(-2.726)	(-0.147)	(-1.812)	(-2.722)	(-10.100)	(-7.147)
Black tea	-17.821 **	-37.247 ***	-0.129	-18.894 ***	27.224 ***	-30.730 ***	-58.666 ***	-54.371 ***
	(-2.517)	(-5.186)	(-0.018)	(-2.645)	(3.868)	(-4.250)	(-7.668)	(-7.495)
Tea beverage	17.071 ***	5.445 **	-2.119	6.114 **	-9.149 ***	-14.690 ***	-17.269 ***	-25.539 ***
	(7.458)	(2.345)	(-0.920)	(2.647)	(-4.019)	(-6.284)	(-6.982)	(-10.888)
Coffee	-11.171 ***	-10.436 ***	-0.848	-5.003 *	0.020	12.273 ***	3.686	20.644 ***
	(-4.107)	(-3.781)	(-0.310)	(-1.822)	(0.007)	(4.418)	(1.255)	(7.409)
Coffee beverage	-4.446	0.347	-7.149 **	-2.144	-0.722 ***	12.050 ***	49.153 ***	27.750 ***
	(-1.510)	(0.116)	(-2.414)	(-0.722)	(-4.880)	(4.007)	(15.445)	(9.196)
Fruit & vegetable juice	4.227 **	6.535 ***	5.027 **	2.367	7.271 ***	0.938	17.928 ***	5.418 ***
	(2.366)	(3.604)	(2.797)	(1.312)	(4.092)	(0.514)	(9.285)	(2.959)
Carbonated beverage	4.452	-3.725	-28.170 ***	-20.790 ***	-17.459 ***	-19.011 ***	-9.663 ***	-22.095 ***
	(1.498)	(-1.235)	(-9.426)	(-6.933)	(-5.909)	(-6.265)	(-3.009)	(-7.257)
Milk	1.700 *	-0.340	6.930 ***	3.299 ***	4.706 ***	5.217 ***	2.225 *	7.272 ***
	(1.574)	(-0.310)	(6.380)	(3.027)	(4.382)	(4.730)	(1.906)	(6.571)

Demand q_i	Fukui	Kofu	Nagano	Gifu	Shizuoka	Nagoya	Tsu	Otsu
Green tea	-39.107 ***	-17.078 ***	-1.312	-45.146 ***	86.747 ***	-11.863 ***	-23.045 ***	-31.619 ***
	(-9.083)	(-4.145)	(-0.321)	(-10.895)	(20.888)	(-2.901)	(-5.420)	(-7.470)
Black tea	-64.821 ***	-42.630 ***	-36.073 ***	-52.325 ***	-51.992 ***	-17.142 **	-41.089 ***	-17.562 **
	(-8.590)	(-5.903)	(-5.031)	(-7.202)	(-7.141)	(-2.391)	(-5.514)	(-2.367)
Tea beverage	-24.866 ***	-3.147 **	-11.863 ***	-7.820 ***	-19.102 ***	-19.169 ***	-12.050 ***	-46.212 ***
	(-10.192)	(-1.348)	(-5.117)	(-3.329)	(-8.115)	(-8.270)	(-5.000)	(-19.265)
Coffee	-3.894	-10.730 ***	-2.556	6.180 **	-17.236 ***	7.145 ***	-0.020	15.264 ***
	(-1.344)	(-3.868)	(-0.928)	(2.216)	(-6.164)	(2.594)	(-0.007)	(5.356)
Coffee beverage	58.535 ***	13.070 ***	7.348 **	36.293 ***	-18.088 ***	5.491 *	11.688 ***	6.949 ***
	(18.648)	(4.351)	(2.464)	(12.007)	(-5.973)	(1.842)	(3.771)	(2.252)
Fruit & vegetable juice	12.068 ***	14.538 ***	4.565 ***	7.647 ***	0.169	5.418 ***	2.078	7.643 ***
	(6.336)	(7.976)	(2.523)	(4.170)	(0.092)	(2.994)	(1.105)	(4.082)
Carbonated beverage	-16.395 ***	-6.267 **	-33.353 ***	-16.857 ***	-33.398 ***	-21.621 ***	-32.634 ***	-22.201 ***
	(-5.177)	(-2.068)	(-11.083)	(-5.529)	(-10.931)	(-7.186)	(-10.433)	(-7.130)
Milk	7.674 ***	2.047 *	7.562 ***	7.444 ***	-2.705 **	6.748 ***	13.356 ***	15.678 ***
	(6.666)	(1.859)	(6.914)	(6.719)	(-2.436)	(6.171)	(11.747)	(13.851)

Demand q_i	Kyoto	Osaka	Kobe	Nara	Wakayama	Tottori	Matsue	Okayama
Green tea	-36.193 ***	-35.593 ***	-29.418 ***	-26.476 ***	-50.718 ***	-56.535 ***	11.082 **	-53.640 ***
	(-8.899)	(-8.872)	(-7.069)	(-6.455)	(-12.070)	(-13.582)	(2.761)	(-13.216)
Black tea	-26.406 ***	-40.745 ***	71.569 ***	-2.526	-47.216 ***	-59.630 ***	-50.328 ***	-26.364 ***
	(-3.705)	(-5.795)	(9.813)	(-0.351)	(-6.411)	(-8.174)	(-7.154)	(-3.705)
Tea beverage	-51.950 ***	-35.427 ***	-41.696 ***	-48.149 ***	-42.259 ***	-54.278 ***	-52.944 ***	-40.923 ***
	(-22.541)	(-15.581)	(-17.679)	(-20.714)	(-17.745)	(-23.008)	(-23.275)	(-17.789)
Coffee	24.765 ***	12.507 ***	22.609 ***	23.579 ***	26.111 ***	28.383 ***	5.202 *	21.445 ***
	(9.039)	(4.628)	(8.065)	(8.535)	(9.228)	(10.125)	(1.924)	(7.846)
Coffee beverage	12.778 ***	23.426 ***	-6.424 **	-2.118 **	27.571 ***	19.130 ***	4.924 *	35.092 ***
	(4.311)	(8.010)	(-2.118)	(-2.532)	(9.000)	(6.305)	(1.683)	(11.858)
Fruit & vegetable juice	2.533	10.691 ***	1.809	7.483 ***	10.174 ***	3.588 **	-4.969 **	9.428 ***
	(1.408)	(6.023)	(0.982)	(4.124)	(5.473)	(1.949)	(-2.798)	(5.250)
Carbonated beverage	-20.135 ***	-13.836 ***	-35.220 ***	-37.028 ***	-14.870 ***	-12.892 ***	-40.467 ***	-18.505 ***
	(-6.730)	(-4.688)	(-11.504)	(-12.272)	(-4.810)	(-4.210)	(-13.704)	(-6.197)
Milk	17.306 ***	10.093 ***	14.792 ***	16.609 ***	12.069 ***	21.198 ***	19.797 ***	12.478 ***
	(15.916)	(9.409)	(13.295)	(15.144)	(10.742)	(19.046)	(18.448)	(11.496)

Demand q_i	Hiroshima	Yamaguchi	Tokushima	Takamatsu	Matsuyama	Kochi	Fukuoka	Saga
Green tea	-56.825 ***	-42.862 ***	-57.153 ***	-60.124 ***	-50.560 ***	-42.467 ***	12.397 ***	34.668 ***
	(-14.139)	(-10.447)	(-14.232)	(-14.766)	(-12.256)	(-10.021)	(3.017)	(8.382)
Black tea	-20.683 **	-38.527 ***	-57.124 ***	-28.453 ***	-64.566 ***	-40.620 ***	-18.037 **	-48.753 ***
	(-2.936)	(-5.357)	(-8.115)	(-3.987)	(-8.929)	(-5.467)	(-2.504)	(-6.724)
Tea beverage	-42.757 ***	-35.471 ***	-40.530 ***	-45.435 ***	-50.443 ***	-28.595 ***	-50.400 ***	-38.142 ***
	(-54.242)	(-15.254)	(-17.807)	(-19.688)	(-21.574)	(-11.904)	(-21.641)	(-16.270)
Coffee	23.703 ***	14.838 ***	18.388 ***	16.296 ***	19.116 ***	20.165 ***	17.722 ***	-1.139
	(8.754)	(5.369)	(6.797)	(5.941)	(6.879)	(7.066)	(6.404)	(-0.409)
Coffee beverage	5.873 **	16.611 ***	10.308 ***	13.451 ***	24.655 ***	38.745 ***	-18.147 ***	-8.008 ***
	(2.005)	(5.554)	(3.521)	(4.532)	(8.200)	(12.540)	(-6.059)	(-2.656)
Fruit & vegetable juice	18.564 ***	-2.181	14.014 ***	14.681 ***	26.415 ***	22.486 ***	5.416 ***	1.633
	(10.440)	(-1.202)	(7.887)	(8.149)	(14.473)	(11.993)	(2.979)	(0.892)
Carbonated beverage	-29.344 ***	5.220 *	5.774 **	-7.389 **	-7.375 ***	-11.955 ***	-39.447 ***	-4.666
	(-9.924)	(1.729)	(1.954)	(-2.467)	(-2.430)	(-3.834)	(-13.050)	(-1.534)
Milk	15.177 ***	15.913 ***	13.975 ***	16.482 ***	8.344 ***	-0.892	12.367 ***	4.699 ***
	(14.123)	(14.505)	(13.014)	(15.139)	(7.564)	(-0.787)	(11.257)	(4.249)

Demand q_i	Nagasaki	Kumamoto	Oita	Miyazaki	Kagoshima	Naha	Kawasaki	Kitakyushu
Green tea	58.867 ***	38.361 ***	17.327 ***	32.979 ***	44.508 ***	-51.832 ***	-4.677	26.455 ***
	(13.957)	(9.368)	(4.203)	(7.893)	(10.777)	(-11.832)	(-1.119)	(5.688)
Black tea	-31.162 ***	-59.753 ***	-35.521 ***	-64.853 ***	-62.567 ***	-53.591 ***	-3.288	-45.599 ***
	(-4.215)	(-8.325)	(-4.915)	(-8.854)	(-8.644)	(-6.978)	(-0.449)	(-5.590)
Tea beverage	-42.540 ***	-31.478 ***	-36.451 ***	-8.808 ***	-39.580 ***	39.128 ***	2.258	-50.300 ***
	(-17.796)	(-13.563)	(-15.598)	(-3.719)	(-39.580)	(15.756)	(0.953)	(-19.073)
Coffee	-4.781 *	-6.071 *	2.557	-15.760 ***	-16.181 ***	0.613	-2.498	16.913 ***
	(-1.683)	(-2.201)	(0.921)	(-5.600)	(-5.816)	(0.208)	(-0.888)	(5.398)
Coffee beverage	-14.481 ***	-21.809 ***	-8.315 **	-5.710 *	-24.668 ***	23.729 ***	-3.043	-9.749 ***
	(-21.809)	(-7.306)	(-2.767)	(-1.875)	(-8.195)	(7.430)	(-0.999)	(-2.876)
Fruit & vegetable juice	12.000 ***	-12.825 ***	10.019 ***	1.810 *	14.169 ***	-3.159	2.066	6.150 ***
	(6.431)	(-7.079)	(5.493)	(0.979)	(7.755)	(-1.630)	(1.118)	(2.988)
Carbonated beverage	-22.373 ***	10.184 ***	-27.616 ***	-13.245 ***	-41.987 ***	14.880 ***	-14.516 ***	-19.419 ***
	(-7.211)	(3.380)	(-9.105)	(-4.309)	(-13.819)	(4.617)	(-4.723)	(-5.674)
Milk	-1.721	11.155 ***	6.700 ***	3.189 ***	9.898 ***	1.100	3.299 ***	5.143 ***
	(-1.526)	(10.188)	(6.078)	(2.854)	(8.963)	(0.939)	(2.953)	(4.136)

See notes to Table 1.2.

Appendix 3.A.

Table 3.A. Estimates of rainfall effects at the mean shares

Demand q_i	January		February		March		April		May		June	
Green tea	1.536	***	-0.325		-0.040		-0.071		0.055		0.153	
	(2.695)		(-0.434)		(-0.056)		(-0.122)		(0.122)		(0.517)	
Black tea	-0.439		-0.314		0.083		-0.287		-1.050		0.787	
	(-0.344)		(-0.187)		(0.052)		(-0.220)		(-1.046)		(1.193)	
Tea beverage	-0.299		0.288		-0.989	*	-0.324		0.371		-0.359	*
	(-0.717)		(0.525)		(-1.892)		(-0.759)		(1.131)		(-1.665)	
Coffee	-0.682		0.468		0.610		0.445		-0.223		0.096	
	(-1.480)		(0.773)		(1.055)		(0.945)		(-0.615)		(0.404)	
Coffee beverage	-0.638		-0.616		0.525		-0.056		0.006		-0.059	
	(-1.159)		(-0.851)		(0.760)		(-0.098)		(0.013)		(-0.208)	

(%/°C)

Demand q_i	July		August		September		October		November		December	
Green tea	0.601	**	0.644	*	-0.222		0.134		-0.327		2.466	***
	(2.088)		(1.772)		(-0.809)		(0.399)		(-0.591)		(4.613)	
Black tea	0.224		0.922		0.465		-1.451	*	1.821		0.828	
	(0.349)		(1.135)		(0.758)		(-1.939)		(1.474)		(0.692)	
Tea beverage	-0.265		-0.156		0.196		-0.019		-0.093		-1.243	***
	(-1.259)		(-0.586)		(0.977)		(-0.076)		(-0.231)		(-3.174)	
Coffee	0.040		0.089		0.120		-0.051		0.660		-1.307	***
	(0.170)		(0.304)		(0.543)		(-0.189)		(1.476)		(-3.024)	
Coffee beverage	-0.632	**	-1.125	***	-0.279		0.298		-0.927	*	0.052	
	(-2.271)		(-3.209)		(-1.051)		(0.919)		(-1.737)		(0.100)	

See notes to Table 2.3.

Appendix 4.A.

Table 4.A. Estimates of sunshine effects at the mean shares

Demand q_i	January	February	March	April	May	June
Green tea	1.930 **	2.015 **	-1.027	1.381	-1.773	-1.697
	(2.226)	(2.015)	(-0.897)	(1.234)	(-1.531)	(-1.458)
Black tea	1.222	-2.459	2.879	-3.194	1.551	-1.312
	(0.631)	(-1.100)	(1.124)	(-1.278)	(0.599)	(-0.504)
Tea beverage	-0.822	-1.366 *	-1.369	1.217	1.802 **	1.547 *
	(-1.297)	(-1.868)	(-1.634)	(1.493)	(2.128)	(1.819)
Coffee	-0.761	0.115	1.487	-1.840 **	-0.718	-0.516
	(-1.087)	(0.143)	(1.606)	(-2.046)	(-0.767)	(-0.548)
Coffee beverage	-0.762	-0.518	0.404	-0.052	0.725	1.426
	(-0.910)	(-0.536)	(0.365)	(-0.048)	(0.648)	(1.269)

(%/°C)

Demand q_i	July	August	September	October	November	December
Green tea	-0.572	-0.287	-1.849	-0.042	-2.037	4.163 ***
	(-0.588)	(-0.232)	(-1.407)	(-0.031)	(-1.569)	(4.186)
Black tea	3.023	5.374 *	3.374	-0.376	4.430	5.136 **
	(1.390)	(1.941)	(1.149)	(-0.125)	(1.525)	(2.308)
Tea beverage	0.479	0.782	1.373	3.174 ***	0.275	-2.595 ***
	(0.674)	(0.863)	(1.428)	(3.224)	(0.289)	(-3.566)
Coffee	1.636 **	1.580	-0.565	-2.882 ***	1.123	-3.775 ***
	(2.085)	(1.578)	(-0.532)	(-2.655)	(1.069)	(-4.698)
Coffee beverage	-3.319 ***	-4.735 ***	0.744	0.102	-0.356	2.377 **
	(-3.535)	(-3.960)	(0.586)	(0.079)	(-0.284)	(2.474)

See notes to Table 2.3.

Appendix 5.A.

Table 5.A. Estimates of city effects at the mean shares

Demand q_i	Sapporo	Aomori	Morioka	Sendai	Akita	Yamagata	Fukushima	Mito
Green tea	-37.008 ***	-42.601 ***	-25.843 ***	-6.638 *	-4.007	-2.975	-14.972 ***	-7.165 **
	(-9.259)	(-11.043)	(-6.843)	(-1.910)	(-1.104)	(-0.822)	(-4.399)	(-2.191)
Black tea	-56.967 ***	-81.252 ***	-69.083 ***	-30.510 ***	-57.084 ***	-44.464 ***	-59.443 ***	-47.062 ***
	(-6.370)	(-9.418)	(-8.179)	(-3.926)	(-7.036)	(-5.496)	(-7.814)	(-6.436)
Tea beverage	14.970 ***	2.717	3.122	-1.761	2.324	1.386	15.261 ***	11.939 ***
	(5.122)	(0.963)	(1.130)	(-0.693)	(0.876)	(0.524) *	(6.133)	(4.992)
Coffee	-4.350	6.055 **	15.671 ***	11.652 ***	1.280	-1.702	2.419	-1.911
	(-1.347)	(1.942)	(5.134)	(4.147)	(0.436)	(-0.582)	(0.879)	(-0.723)
Coffee beverage	55.521 ***	71.814 ***	27.177 ***	1.838	15.717 ***	17.040 ***	11.657 ***	8.609 ***
	(14.380)	(19.276)	(7.451)	(0.548)	(4.485)	(4.877)	(3.547)	(2.726)

Demand q_i	Utsunomia	Maebashi	Saitama	Chiba	Yokohama	Niigata	Toyama	Kanazawa
Green tea	-13.814 ***	-0.923	-8.161 **	-4.660	-3.421	-13.018 ***	-34.166 ***	-21.269 ***
	(-4.200)	(-0.284)	(-2.505)	(-1.443)	(-1.061)	(-3.824)	(-9.525)	(-6.236)
Black tea	-27.229 ***	-44.260 ***	-8.486	-27.335 ***	17.785 **	-41.542 ***	-57.051 ***	-54.007 ***
	(-3.704)	(-6.080)	(-1.166)	(-3.787)	(2.468)	(-5.459)	(-7.117)	(-7.086)
Tea beverage	21.677 ***	7.869 ***	3.870	6.349 ***	-4.145 *	-6.525 ***	-12.463 ***	-21.020 ***
	(9.014)	(3.304)	(1.625)	(2.689)	(-1.758)	(-2.621)	(-4.753)	(-8.430)
Coffee	-6.806 **	-5.467 **	3.019	-0.080	6.646 **	9.954 ***	11.303 ***	24.645 ***
	(-2.559)	(-2.076)	(1.146)	(-0.030)	(2.549)	(3.616)	(3.898)	(8.937)
Coffee beverage	6.708 **	10.334 ***	3.849	4.950	-4.209	24.237 ***	66.826 ***	37.758 ***
	(2.112)	(3.286)	(1.223)	(1.587)	(-1.352)	(7.372)	(19.297)	(11.466)

Demand q_i	Fukui	Kofu	Nagano	Gifu	Shizuoka	Nagoya	Tsu	Otsu
Green tea	-28.734 ***	-9.425 ***	-1.638	-34.219 ***	49.989 ***	-5.829 *	-15.176 ***	-12.252 ***
	(-8.211)	(-2.872)	(-0.464)	(-10.410)	(15.198)	(-1.819)	(-4.577)	(-3.589)
Black tea	-59.674 ***	-42.678 ***	-44.619 ***	-47.630 ***	-60.556 ***	-20.550 ***	-43.162 ***	-9.342
	(-7.631)	(-5.819)	(-5.661)	(-6.483)	(-8.238)	(-2.870)	(-5.824)	(-1.225)
Tea beverage	-13.306 ***	5.081 **	-1.764	-7.896 ***	-15.468 ***	-15.009 ***	-4.699 *	-36.198 ***
	(-5.201)	(2.117)	(-0.684)	(-3.285)	(-6.432)	(-6.407)	(-1.938)	(-14.504)
Coffee	4.378	-4.028	-5.804 **	21.548 ***	-13.692 ***	14.475 ***	10.830 ***	31.887 ***
	(1.547)	(-1.518)	(-2.036)	(8.106)	(-5.148)	(5.586)	(4.039)	(11.552)
Coffee beverage	71.864 ***	24.510 ***	26.430 ***	40.940 ***	-13.605 ***	13.159 ***	23.764 ***	23.187 ***
	(21.272)	(7.735)	(7.763)	(12.898)	(-4.284)	(4.253)	(7.422)	(7.035)

Demand q_i	Kyoto	Osaka	Kobe	Nara	Wakayama	Tottori	Matsue	Okayama
Green tea	-11.988 ***	-14.982 ***	-14.524 ***	-10.221 ***	-33.414 ***	-30.276 ***	26.554 ***	-36.751 ***
	(-3.705)	(-4.686)	(-4.378)	(-2.983)	(-9.878)	(-9.042)	(8.172)	(-11.270)
Black tea	-22.370 ***	-35.753 ***	74.437 ***	-8.518	-41.927 ***	-47.457 ***	-44.230 ***	-19.832 ***
	(-3.093)	(-5.004)	(10.039)	(-1.112)	(-5.546)	(-6.342)	(-6.090)	(-2.721)
Tea beverage	-42.788 ***	-29.541 ***	-35.272 ***	-33.962 ***	-37.080 ***	-39.627 ***	-44.213 ***	-32.162 ***
	(-18.086)	(-12.637)	(-14.541)	(-13.556)	(-14.992)	(-16.190)	(-18.610)	(-13.489)
Coffee	38.539 ***	27.836 ***	33.468 ***	33.777 ***	46.415 ***	44.637 ***	14.620 ***	38.279 ***
	(14.728)	(10.766)	(12.474)	(12.192)	(16.967)	(16.488)	(5.563)	(14.516)
Coffee beverage	25.312 ***	30.979 ***	0.276	13.510 ***	41.414 ***	44.867 ***	14.201 ***	46.392 ***
	(8.101)	(10.034)	(0.086)	(4.083)	(12.679)	(13.879)	(4.526)	(14.733)

Demand q_i	Hiroshima	Yamaguchi	Tokushima	Takamatsu	Matsuyama	Kochi	Fukuoka	Saga
Green tea	-31.954 ***	-24.822 ***	-24.757 ***	-27.217 ***	-26.599 ***	-34.080 ***	26.902 ***	41.459 ***
	(-9.928)	(-7.601)	(-7.710)	(-8.379)	(-7.938)	(-10.264)	(8.115)	(12.806)
Black tea	-9.425	-28.157 ***	-48.735 ***	-10.720	-57.776 ***	-43.024 ***	-15.913 **	-47.560 ***
	(-1.310)	(-3.858)	(-6.791)	(-1.477)	(-7.714)	(-5.798)	(-2.148)	(-6.572)
Tea beverage	-30.789 ***	-23.781 ***	-29.502 ***	-33.695 ***	-37.271 ***	-21.617 ***	-44.398 ***	-33.399 ***
	(-13.083)	(-9.961)	(-12.567)	(-14.188)	(-15.212)	(-8.905)	(-18.316)	(-14.109)
Coffee	44.668 ***	28.156 ***	40.951 ***	37.767 ***	38.847 ***	30.471 ***	25.159 ***	2.375
	(17.161)	(10.662)	(15.771)	(14.378)	(14.335)	(11.350)	(9.384)	(0.907)
Coffee beverage	23.985 ***	34.613 ***	27.784 ***	32.756 ***	47.981 ***	45.502 ***	-10.715 ***	-3.572
	(7.717)	(10.977)	(8.961)	(10.444)	(14.829)	(14.193)	(-3.347)	(-1.142)

Demand q_i	Nagasaki	Kumamoto	Oita	Miyazaki	Kagoshima	Naha	Kawasaki	Kitakyushu
Green tea	56.245 ***	47.510 ***	26.241 ***	32.206 ***	61.643 ***	-37.829 ***	-5.497 *	35.350 ***
	(16.768)	(14.388)	(8.077)	(9.881)	(18.358)	(-9.501)	(-1.699)	(10.362)
Black tea	-41.678 ***	-61.935 ***	-43.006 ***	-67.994 ***	-59.641 ***	-52.086 ***	-16.753 **	-53.138 ***
	(-5.560)	(-8.392)	(-5.923)	(-9.333)	(-7.946)	(-5.848)	(-2.317)	(-6.969)
Tea beverage	-40.765 ***	-28.489 ***	-27.874 ***	-7.313 ***	-35.407 ***	28.421 ***	9.065 ***	-39.736 ***
	(-16.621)	(-11.799)	(-11.734)	(-3.068)	(-14.421)	(9.763)	(3.831)	(-15.930)
Coffee	-0.876	3.157	7.972 ***	-9.241 ***	-1.427	15.199 ***	-4.360 *	11.757 ***
	(-0.323)	(1.182)	(3.034)	(-3.506)	(-0.525)	(4.724)	(-1.666)	(4.262)
Coffee beverage	-11.078 ***	-17.422 ***	0.741	-4.305	-21.497 ***	3.637	6.276 **	1.329
	(-3.420)	(-5.463)	(0.236)	(-1.368)	(-6.630)	(0.945)	(2.009)	(0.403)

See notes to Table 2.3.

Appendix 6.A.

Table 6.A Estimates of city effects at the mean shares

Demand q_i	Sapporo	Aomori	Morioka	Sendai	Akita	Yamagata	Fukushima	Mito
Beans/Powder	1.662 ***	-7.739 ***	19.669 ***	15.101 ***	18.940 ***	8.675 ***	8.100 ***	5.735 ***
	(7.023)	(-4.600)	(10.020)	(7.834)	(9.710)	(4.220)	(4.139)	(3.029)
Canned/Bottled	-1.488 ***	20.568 ***	-14.075 ***	-23.632 ***	-6.483 ***	-6.163 **	-9.931 ***	-10.885 ***
	(-5.219)	(10.120)	(-5.927)	(-10.148)	(-2.752)	(-2.473)	(-4.210)	(-4.751)
Coffee Shops	-0.893 ***	-6.681 ***	-13.377 ***	-0.077	-18.499 ***	-5.935 **	-2.223	1.489
	(-2.873)	(-3.018)	(-5.177)	(-0.030)	(-7.211)	(-2.194)	(-0.865)	(0.597)

Demand q_i	Utsunomia	Maebashi	Saitama	Chiba	Yokohama	Niigata	Toyama	Kanazawa
Beans/Powder	-3.305 *	4.483 **	-4.721 **	-2.574	-5.910 ***	-2.650	-5.083 **	6.951 ***
	(-1.709)	(2.283)	(-2.457)	(-1.334)	(-3.117)	(-1.356)	(-2.392)	(3.406)
Canned/Bottled	-7.439 ***	-5.380 **	-18.457 ***	-14.918 ***	-29.055 ***	-13.817 ***	21.879 ***	3.147
	(-3.187)	(-2.264)	(-7.983)	(-6.425)	(-12.732)	(-5.877)	(8.544)	(1.281)
Coffee Shops	10.040 ***	-1.323	20.564 ***	15.070 ***	30.471 ***	14.290 ***	-11.040 ***	-11.181 ***
	(3.948)	(-0.511)	(8.159)	(5.955)	(12.249)	(5.576)	(-3.956)	(-4.176)

Demand q_i	Fukui	Kofu	Nagano	Gifu	Shizuoka	Nagoya	Tsu	Otsu
Beans/Powder	-20.840 ***	-10.340 ***	-2.472	-6.215 ***	-6.365 ***	-4.298 **	-7.747 ***	1.599
	(-9.993)	(-5.293)	(-1.260)	(-2.720)	(-3.078)	(-2.119)	(-3.863)	(0.822)
Canned/Bottled	21.384 ***	-5.151 **	-7.971 ***	8.305 ***	-26.515 ***	-14.748 ***	-9.790 ***	-16.399 ***
	(8.512)	(-2.189)	(-3.371)	(3.020)	(-10.655)	(-6.042)	(-4.056)	(-6.991)
Coffee Shops	9.029 ***	17.007 ***	9.422 ***	1.161	29.020 ***	17.088 ***	17.455 ***	11.036 ***
	(3.298)	(6.630)	(3.659)	(0.387)	(10.698)	(6.421)	(6.634)	(4.318)

Demand q_i	Kyoto	Osaka	Kobe	Nara	Wakayama	Tottori	Matsue	Okayama
Beans/Powder	2.170	-13.245 ***	-5.586 ***	-2.643	-4.689 **	5.024 **	6.604 ***	2.112
	(1.136)	(-6.977)	(-2.861)	(-1.341)	(-2.392)	(2.509)	(3.417)	(1.111)
Canned/Bottled	-16.597 ***	-8.139 ***	-32.495 ***	-33.316 ***	-9.218 ***	-7.746 ***	-10.737 ***	2.247
	(-7.198)	(-3.562)	(-13.792)	(-14.046)	(-3.894)	(-3.214)	(-4.590)	(0.977)
Coffee Shops	10.480 ***	23.008 ***	32.800 ***	29.777 ***	13.181 ***	-0.117	0.286	-4.423 *
	(4.175)	(9.238)	(12.783)	(11.517)	(5.114)	(-0.045)	(0.112)	(-1.768)

Demand q_i	Hiroshima	Yamaguchi	Tokushima	Takamatsu	Matsuyama	Kochi	Fukuoka	Saga
Beans/Powder	8.132 ***	1.003	10.689 ***	2.751	-0.780	-6.652 ***	1.007	-0.885
	(4.321)	(0.525)	(5.625)	(1.448)	(-0.404)	(-3.467)	(0.528)	(-0.458)
Canned/Bottled	-15.309 ***	-1.896	-4.531 **	-6.658 ***	-1.249	-1.205	-37.771 ***	-17.291 ***
	(-6.757)	(-0.824)	(-1.978)	(-2.912)	(-0.536)	(-0.521)	(-16.456)	(-7.431)
Coffee Shops	2.011	0.254	-9.747 ***	1.856	1.967	9.264 ***	28.760 ***	14.846 ***
	(0.814)	(0.101)	(-3.907)	(0.745)	(0.776)	(3.680)	(11.503)	(5.855)

Demand q_i	Nagasaki	Kumamoto	Oita	Miyazaki	Kagoshima	Naha	Kawasaki	Kitakyushu
Beans/ Powder	-6.288 ***	8.842 ***	9.371 ***	-3.617 *	1.977	-5.904 ***	0.074	8.546 ***
	(-3.181)	(4.510)	(4.851)	(-1.853)	(1.004)	(-2.860)	(0.038)	(4.284)
Canned/Bottled	-32.789 ***	-27.443 ***	-9.760 ***	-6.099 ***	-25.764 ***	12.079 ***	-6.206 ***	-18.302 ***
	(-13.785)	(-11.612)	(-4.198)	(-2.589)	(-10.876)	(4.862)	(-2.664)	(-7.617)
Coffee Shops	33.911 ***	10.768 ***	-3.945	9.363 ***	18.006 ***	-2.227	4.839 *	3.872
	(13.075)	(4.186)	(-1.557)	(3.646)	(6.970)	(-0.822)	(1.906)	(1.478)

See notes to Table 4.3.

SUMMARY (ENGLISH)

Demand System Analysis of Coffee in the Japanese Households

Coffee is one of the most demanded agricultural commodities in the world. The coffee beverage market is one of the biggest industries globally, estimated more than $100 billion dollars worth. Over the past 4 years, global coffee consumption has been increasing by 2.4% annually. Japan, which has seen its coffee demand increase significantly over the past few years, is one of the top coffee-consuming nations, after the United States, Brazil, and Germany. The Japanese coffee beverage market consist of several coffee product categories; mainly, coffee beans and powder, canned and bottled coffee, coffee containing milk beverage, and coffee containing soft drinks.

As a popular beverage, coffee has been an interest of study for many researchers, economists, and policy makers over the past several years. Several studies were conducted using various estimation models for coffee product categories analyzing mostly income and price elasticities in different countries. With regards to Japanese coffee demand, however, studies have been few to none. In Japan, the rise for coffee consumption can be attributed to several dynamics such as influences from western consumption lifestyles, growth of promotional strategy on ready-to-drink coffee beverages, and the rapid expansion in the number of coffee brands and coffee shops throughout Japan.

To be more precise, however, there are several factors that possibly play a role in the consumer demand for coffee beverages. Some of these factors may include responses to changes in its expenditure and price, demographic factors, taste and preference, and weather to mention few. This thesis, therefore, attempts to provide a comprehensive demand system analysis of coffee consumption in the Japanese household from a regional, city level point of view, taking into account factors such as expenditure and price changes, demographic, and weather effects among others. More specifically, this thesis assess the significance of demographic factors on coffee demand in Japan; evaluate regional differences in Japanese coffee demand in consumption; evaluate weather effect on coffee demand in Japan; estimate non-alcoholic beverages demand in Japanese household and evaluate substitution between

coffee product categories in Japan. One of the main reasons why we chose Japan has our study area is because Japan is one of the top coffee consuming nations globally. Therefore, understanding its consumption behavior has an important policy implication for beverage manufacturing companies.

The quadratic almost ideal demand system (QUAIDS) model, which was developed from utility maximization by Banks et al. (1997), not only applies the desirable properties of Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) model but also is more versatile in modeling consumer expenditure patterns. The QUAIDS model gives rise to quadratic logarithmic engel curves, whereas in the case of AIDS, the elasticities are not dependent of expenditure level. This thesis employs the linear version of QUAIDS (LA/QUAIDS) model by Matsuda (2006). We chose this specific model, LA/QUAIDS, because it has the characteristics of 'Closure Under Unit Scaling' (CUUS), even with demand shifters such as demographic variables, monthly and city dummies (Alston et al., 2001). With demand shifters, the original QUAIDS of Banks et al. (1997) does not satisfy CUUS. According to Pollack and Wales (1992), CUUS is a property that ensures that estimated economic effects are constant to the scaling of the data. In addition, Pollack and Wales (1980) stated that only demand systems consistent with CUUS should be used for empirical demand analysis.

The data used in this thesis was attained from the Family income and Expenditure Survey of Japan (FIES), conducted by the Ministry of Internal Affairs and Communication, for two or more persons' household using monthly data in 49 major cities. The use of aggregate pseudo panel data enables us to analyze the impact of the important demographic and weather variables affecting coffee and other non-alcoholic beverages consumption patterns in Japan. Considering the changes in prices, all expenditure data for coffee and other non-alcoholic beverages were deflated using the consumer price index. To evaluate the temperature effects, monthly data were outsourced from Japan Meteorological Agency (JMA).

Using the LA/QUAIDS model, the results attained are as follows: The estimated results for the non-alcoholic beverages in Japan reveal that expenditure for green tea, black tea, coffee, and fruit and vegetable juice was found to be elastic implying a luxury goods, whereas tea beverage, coffee beverage, and milk was found to be inelastic implying necessity goods in the household. The uncompensated own-price elasticity show that demand for green tea, black tea, tea beverage, coffee, coffee beverage, and carbonated beverage as own-price elastic while demand for fruit and vegetable juice and milk as inelastic. As for the cross-price elasticities both uncompensated and compensated show the beverages as mostly complementary goods. As for demographic effect, the results shows that people under the age of 18 prefer milk and fruit and vegetable juice than any other beverages whereas people over the age of 65 prefer green tea in addition to milk. The findings indicate a strong correlation between consumer behavior and health against its dietary implication in the Japanese household. As for seasonal effects, the results indicate that when temperature rises by 1 degree Celsius, consumers drink more tea beverage, coffee beverage, fruit and vegetable juice, and carbonated beverage whereas when temperature drops by 1 degree Celsius, consumers prefer more green tea, black tea, and coffee. The explanation could be that since green tea, black tea, and coffee are usually served as a hot beverage and they are usually consumed at home whereas beverages such as tea beverage, coffee beverage, fruit and vegetable juice and carbonated beverage are served cold and are often drunk in convenience shops and through vending machines. Consequently, this study has implication for dairy manufacturers to produce new milk products, targeting children and elderly people, based on the findings of our study.

Regarding weather effects on household demand for coffee and tea in Japanese household, the estimated result shows that expenditure elasticities for green tea and black tea as elastic, implying luxury goods, whereas tea beverage, coffee and coffee beverage show they are inelastic, implying a necessity good. The uncompensated own-price elasticities reveals that green tea has the most own-price elastic demand and coffee has the most own-price inelastic. The compensated cross-price elasticities show most of the beverages as complementary goods.

As for demographic effects, the result shows that green tea as a preferred beverage among elderly people, while adults prefer more tea beverage and coffee beverage. In reality, the outcome makes sense since green tea is usually consumed for its health benefits and tea beverage and coffee beverage are drinks accessible through vending machine. Global warming, which is the gradual rise of temperature has a significant impact on household demand for coffee in Japan throughout the year. The result reveals that when temperature rises by 1 degree Celsius consumers drink more green tea, black tea, and coffee whereas when temperature drops by 1 degree Celsius consumers drink more tea beverage and coffee beverage. Consequently, our results have implications for beverage marketing strategy. Based on our results, particularly the temperature findings, beverage manufacturers can produce and supply their beverages according to the seasonal changes.

As for the study regarding substitution in consumer demand for coffee product categories in Japan, the estimation results show the expenditure elasticities for coffee shops to be elastic implying a luxury good, while demand for beans/powder and canned/bottled as inelastic indicating a necessity good. The uncompensated own-price elasticities reveal that coffee shops are own-price elastic whereas beans/powder and canned/bottled as own-price inelastic. As for the compensated cross-price elasticity the study reveals that all coffee product categories are substitutes for one another.

As for demographic effects is a concerned, elderly person and people who earn more tend to consume coffee at coffee shops. Temperature effects also play a significant role on the responsiveness of coffee consumption in Japan. The result reveals that when temperature rises by 1 degree Celsius, people consume more canned/bottled beverages, whereas when temperature drops by 1 degree Celsius, consumers favor to drink coffee at coffee shops. This study carries important implications. As our findings revealed, all three coffee product categories are substitutes to one another. Consequently, this implicates competition among coffee suppliers, which will help further expand coffee demand in Japan.

SUMMARY (JAPANESE)

Demand System Analysis of Coffee in the Japanese Households

日本の家計におけるコーヒーの需要システム分析

要 旨

本学位論文は，大標本の月別・都市別疑似パネルデータとシステム回帰モデルを駆使し，日本におけるコーヒーの家計需要を実証的に分析したもので，主要部分は 5 章から成り立っている．

まず第 1 章では，序論として本学位論文の背景，問題意識，分析方法，および論文の構成を概観している．

つづく第 2 章では，Deaton（2015 年ノーベル経済学賞受賞者）and Muellbauer (1980)の linear approximate almost ideal demand system (LA/AIDS)を拡張した quadratic LA/AIDS (LA/QUAIDS, Matsuda, 2006)という需要関数のシステム回帰モデル（需要システム）を用い，コーヒーを含む非アルコール飲料 8 品目の家計需要を推定している．分析の結果，非アルコール飲料の中でコーヒー（豆または粉末）はやや奢侈財的性格が強く，果物・野菜ジュースと代替関係にあること，また，コーヒー飲料（缶またはボトル）はやや必需財的性格が強く，牛乳と代替関係にあることなどを定量的に明らかにしている．

第 3 章では，特に気象要因がコーヒー，コーヒー飲料，緑茶，紅茶，茶飲料の 5 品目の家計需要に与える影響に着目し LA/QUAIDS を推定している．分析の結果，コーヒーとコーヒー飲料の需要は自己価格に対して非弾力的で，緑茶，紅茶，茶飲料の需要は自己価格に対して弾力的であること，温かくして飲むことが多いコーヒー，緑茶，紅茶は年間を通して気温が上がると需要が減少すること，冷たくして飲むことが多いコーヒー飲料と茶飲料は年間を通して気温が上がると需要が増加し，こうした気温が需要に与えるプラスの効果は特に夏季に大きいこと，コーヒー飲料と茶飲料の需要は増加トレンド，コーヒーと緑茶の需要は減少トレンドであること，家計内の 65 歳以上人員が 1 人増加するとコーヒーの需要は約 19%減少し，緑茶の需要は約 31%増加すること，また，家計内の 18 歳以上人員が 1 人増加するとコーヒー飲料と茶飲料の需要はそれぞれ約 10%，約 4%増加し，緑茶の需要は約 12%減少することなどを明らかにしている．

第 4 章では，コーヒー，コーヒー飲料，喫茶（外食）の 3 品目の家計需要の代替・補完関係に焦点を当てて LA/QUAIDS を推定している．分析の結果，3 品目は相互に代替財であること，支出弾力性と非補償自己価格弾力性（の絶対値）はいずれも喫茶が最大，コーヒー飲料が最小で，特に喫茶の奢侈財的性格が顕著であること，コーヒー飲料の需要は増加トレンド，コーヒーと

喫茶の需要は減少トレンドであること，また，世帯主の年齢の上昇とともにコーヒーの需要は増加し，コーヒー飲料と喫茶の需要は減少することなどを明らかにしている．

最後に第 5 章では，本研究全体のまとめと結論の提示を行っている．

LIST OF PUBLICATIONS

Title: Demand Analysis of Non-Alcoholic Beverages in Japan
Authors: Michael Fesseha Yohannes and Toshinobu Matsuda
Journal Name: Journal of Agricultural Science
Issue: Vol. 7, No. 5: 143-153
Section Covered: Chapter 2: Demand Analysis of Non-Alcoholic Beverages in Japan

Title: Weather Effects on Household Demand for Coffee and Tea in Japan
Authors: Michael Fesseha Yohannes and Toshinobu Matsuda
Journal Name: Agribusiness: An International Journal
Issue: Vol. 32, No. 1: 33-44
Section Covered: Chapter 3: Weather Effects on Household Demand for Coffee and Tea in Japan

Title: Substitution in Consumer Demand for Coffee Product Categories in Japan
Authors: Michael Fesseha Yohannes, Toshinobu Matsuda, and Naoko Sato
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