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https://doi.org/10.5109/4363563

出版情報：九州大学大学院農学研究院紀要. 66 (1), pp.155-162, 2021-03-01. Faculty of Agriculture, Kyushu University
バージョン：
権利関係：

J. Fac. Agr., Kyushu Univ., **66** (1), 155–162 (2021)

Identifying Factors for Expanding Japanese Green Tea Exports to the United States: From Changes in Demand Structure in the United States

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(*Received October 30, 2020 and accepted November 4, 2020*)

This study econometrically analyzes the factors driving the expansion of Japanese green tea exports to the United States. We estimate the green tea demand structure after classifying green tea imported into the United States into three sources: Japan, China, and the rest of the world. Given that the share of the import value of Japanese green tea changed from a decrease to an increase from 2006 onwards, the analysis period is divided into January 1994 to December 2005 (the first period) and January 2006 to December 2017 (the second period). In addition, based on the estimation results, we evaluate the extent to which influencing factors such as changes in prices and preferences contributed to changing the import value share of Japanese green tea. The main analysis results are as follows. First, Japanese green tea demand is different from that of China and the rest of the world. In addition, the absolute value of the price and expenditure elasticity of demand for Japanese green tea are lower than those for Chinese green tea. Second, Japanese green tea became more popular among Americans in the second period. Third, the decrease in the value share of Japanese green tea imports in the first period was due to the increase in expenditure on green tea in the United States and the low expenditure elasticity of demand for Japanese green tea. The increase in the value share of Japanese green tea imports in the second period was due to the change in preferences.

Key words: Contribution analysis, Japanese green tea, Time series analysis, US demand

OBJECTIVE

Green tea is one of the most important agricultural exports of Japan[1]. The export value has increased year by year from 1.2 billion yen in 2001 to 14.4 billion yen in 2017. The top destination for Japanese green tea exports is the United States; in recent years, about 40% of total exports have been to the United States.

The Tea Association of the USA Inc. (2019) reported that the sale of tea increased by 15.3% from 2014 to 2017, and "The industry anticipates strong, continuous growth, with a CAGR of 3–5%. This growth will come from all segments driven by variety, convenience, health benefits, sustainability, availability, continued innovation and the discovery of unique, flavorful and high–end specialty tea. Long term success relies on the continued adoption of tea by new consumers who continually seek healthy food and beverage choices." Furthermore, according to their survey, the consumption of tea was more than 3.8 billion gallons in the United States in 2017, 13% of which was green tea. In addition, the Tea Association of the U.S.A. Inc. (2019) states the following about Matcha, which is powdered green tea, "Matcha continues to drive consumer interest and is a favorite among health conscious consumers and beverage drinkers" and "Matcha is also very versatile and can be prepared and enjoyed in many different ways."

Figure 1 shows the trend of import value share of green tea from each country into the United States. As shown, Chinese green tea traditionally occupied the top import value share. However, due to rapid export expansion from 2006, Japanese green tea accounted for the largest share of import value in 2017. It is considered important to clarify the cause of this rapid expansion of exporting agricultural products from Japan.

In the studies that cover demand for green tea in the United States—for example, Zheng and Kaiser (2008), Zhen *et al*. (2010), Dharmasena and Capps (2012), Sharma *et al*. (2014), and Dharmasena *et al*. (2014)—green tea is grouped under the broad labels of "tea" or "coffee and tea." No studies have analyzed the demand for green tea independently or the relationship among the green teas produced in each export country.

Therefore, the aim of this study is to econometrically analyze the factors causing the expansion of Japanese green tea exports to the United States. Specifically, after classifying imported green tea in the United States into three items based on source—Japanese, Chinese, and Rest of the World (RoW)—and based on the fact that the share of import value of Japanese green tea changed from a decrease to an increase from 2006 onwards, we clarify the change in the demand structure for green tea in the United States before and after 2005. In addition, based on the estimation results, we evaluate how much each factor, such as changes in prices and preference, contributed to the import value share change.

The remainder of this paper is structured as follows. First, the estimation method of the green tea demand structure in the United States is described in Section 2.

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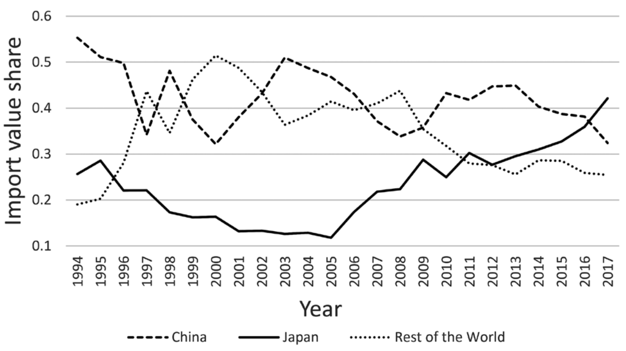

Fig. 1. Trends in value share of imported green tea in the United States
Data Source: United States Department of Agriculture (2018)

Second, after outlining the data in Section 3, Section 4 clarifies the change in the green tea demand structure in the United States after conducting unit root testing. Third, in Section 5, a contribution analysis of import value share change is performed. Finally, Section 6 provides a summary of this paper.

ESTIMATION METHODS

Consumer demand system

This study uses the consumer demand system to estimate the green tea demand structure in the United States. This system can simultaneously handle multiple goods and can be derived from the consumption theory of microeconomic theory. In this study, demand structure is estimated using the linear approximated almost ideal demand system (LA/AIDS) model, which is a linear approximation version of the AIDS (Deaton and Muellbauer, 1980) model. The LA/AIDS model can be expressed as follows.

$$w_{it} = \alpha_i + \beta_i \ln\left(\frac{Y_t}{P_t}\right) + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + t_i TR_t + \sum_{s=2}^{12} d_{is} DM_s + e_{it} \qquad (1)$$

Here, w_{it} is the import value share of item i; Y_t is the total import value of the target items; p_{jt} is the import price of the item i; TR_t is a time trend variable; α_i, β_i, γ_{ij}, t_i, and d_{is} are the parameters; and e_{it} is the error term of item i. Subscripted t represents the period t. In addition, DM_s is a monthly dummy variable that takes 1 for month s, 0 otherwise.

Furthermore, for the price index in the aforementioned models, the following log–linear analog of the Laspeyres price index is used.

$$\ln P_t = \sum_{i=1}^{n} \overline{w}_i \ln p_{it} \qquad (2)$$

However, $\overline{w}_i$ is the sample mean value of the import value share of item i. In estimating equation (1), the adding–up constraint ($\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \gamma_{ij} = \sum_{i=1}^{n} \beta_i = \sum_{i=1}^{n} t_i = \sum_{i=1}^{n} d_{is} = 0$), homogeneity constraint ($\sum_{j=1}^{n} \gamma_{ij} = 0$), and symmetry constraint ($\gamma_{ij} = \gamma_{ji}$) are imposed.

Estimation method of error correction model

Most time–series data are considered to be in a non–stationary process, and when regression estimation is performed using non–stationary time–series data, there is a possibility that the estimation becomes spurious and the reliability of the analysis is impaired. Therefore, we estimate the dynamic LA/AIDS model following Karagiannis *et al.* (2000)[2].

According to Karagiannis *et al.* (2000), if the original series of each variable is in a non–stationary process and the difference series of each variable is in a stationary process, the existence of a co–integration relationship is tested by estimating the following error correction model.

$$\Delta w_{it} = \theta_i \Delta w_{it-1} + \beta_i \Delta \ln\left(\frac{Y_t}{P_t}\right) + \sum_{j=1}^{n} \gamma_{ij} \Delta \ln p_{jt} + \lambda_i \mu_{it-1} + u_{it} \qquad (3)$$

Here, Δ represents a difference, μ_{it-1} is the residuals in a previous period estimated from the static LA/AIDS model, and θ_i and λ_i are parameters. There is a co–integration relationship if λ_i is statistically significant. If λ_i is not statistically significant, it is judged that there is no co–integration relationship[3].

However, in the error correction model of Karagiannis *et al.* (2000), since θ_i and λ_i do not have the same value in the share equations, the adding–up constraint is not satisfied. Therefore, in this study, as with Rathnayaka *et al.* (2019), θ_i and λ_i are assumed to have the same value in the share equations ($\theta = \theta_1 = \theta_2 = \theta_3$, $\lambda = \lambda_1 = \lambda_2 = \lambda_3$).

Based on the above, the demand structure is estimated by the following model.

$$\Delta w_{it} = t_i + \theta \Delta w_{it-1} + \beta_i \Delta \ln\left(\frac{Y_t}{P_t}\right) + \sum_{j=1}^{n} \gamma_{ij} \Delta \ln p_{jt} + \sum_{s=2}^{12} d_{is} \Delta DM_s + \lambda \mu_{it-1} + u_{it} \qquad (4)$$

First, we estimate equation (1) and calculate μ_{it-1}, and we then estimate equation (4) using μ_{it-1}.

In the estimation procedure, after excluding the share equation of RoW's green tea, the share equations

[1] Tea is classified into six types according to the difference in fermentation. Among them, green tea is a non–fermented tea. The other five types are fermented tea (also known as post–fermented tea or dark tea). In this paper, the analysis is limited to green tea.

[2] Other than Karagiannis *et al.* (2000), there are many studies that incorporate an LA/AIDS model into an error correction model. For example, Attfield (1997), Fanelli and Mazzocchi (2002), Karagiannis and Mergos (2002), Duffy (2003), and Nzuma and Sarker (2010).

[3] According to Karagiannis *et al.* (2000), "A shortcoming of the Johansen procedure in the case of applied consumer demand analysis is that there is no a priori information to exclude some vectors as theoretically inconsistent whenever more than one cointegrated vector is found," and static co–integration tests have low discriminatory power against alternative hypothesis, so a dynamic modeling procedure is recommended by Banerjee *et al.* (1986) and Kremers *et al.* (1992).

of the Japanese and the Chinese green teas are simultaneously estimated using the iterative seemingly unrelated regression. In addition, the parameters of the share equation of RoW's green tea will be estimated using constraints and estimation results.

DATA

The subjects of the analysis are three imported green teas: Japanese green tea (i = 1), Chinese green tea (i = 2), and RoW green tea (i = 3)[4]. The analysis period is divided into January 1994 to December 2005 (the first period) and January 2006 to December 2017 (the second period) as the value share of imports of Japanese green tea changed from a decrease to an increase from 2006 onwards. We estimate the demand structure for each period to capture its change.

The import price of each country is obtained by dividing the import value by the import quantity. In addition, the import value of each country is converted to a real value using "All items" in the "All Urban Consumer Price Index."

The data on import value and import quantity are obtained from the United States Department of Agriculture (2018), and the Consumer Price Index data are obtained from the United States Department of Labor (2018)[5].

RESULT OF ANALYSIS

Unit root test

For the variables used in the LA/AIDS model, and the natural logarithms of the relative price variables, an augmented Dickey–Fuller (ADF) test (Dickey and Fuller, 1979) and a Phillips–Perron (PP) test (Phillips and Perron, 1988) are carried out on each of the following: (1) the original series, (2) the difference series (first difference from one period before), and (3) the seasonal difference series (first difference from 12 periods before). In addition, we conduct unit roots tests for the first and second periods, and the results are shown in Table 1 and Table 2, respectively[6].

First, for the original series, in both the first and second periods, although the null hypothesis can be rejected for all variables in the PP test at the 1% level, for four variables in the ADF test, the null hypothesis cannot be rejected at the 10% level. Regarding the seasonal difference series, in both the first and second periods, the null hypothesis can be rejected for all variables in the PP test at the 1% level, but for one or two variables in the ADF test, the null hypothesis cannot be rejected at the 10% level. By contrast, for the difference series, in both tests, the null hypothesis can be rejected for all variables at the 1% level in both the first and second periods. That is, all variables become stationary processes by taking the first difference from one period before.

Demand structure change of green tea in the United States

The estimation results of equations (1) and (4) are as shown in Tables 3 and 4, respectively[7]. We estimate the long–term elasticity using the parameters obtained from the estimation of equation (1) and the short–term elasticity using the parameters obtained from the estimation of equation (4)[8]. Estimated results of price and expenditure elasticity of short– and long–term demand are presented in Table 5. Based on the above estimation results, we consider the change in demand structure for green tea in the United States.

First, we consider the cross–price elasticity of demand. Focusing on Japanese green tea demand, the elasticity to Chinese green tea price is statistically significantly positive in the short term of the first period, but its value (0.052) is very small. Additionally, although the elasticity to RoW's green tea price is statistically significant in the short term of the second period, its value is negative. No significant value is estimated in the long term in either the first period or second term. Therefore, Japanese green tea demand is considered different from Chinese and RoW green tea.

In addition, when considering the elasticity of demand for RoW's tea to the price of Chinese green tea, the short–term elasticity is 0.156, and long–term elasticity is 0.184 in the second period, both values being significant. That is, since 2006, RoW's green tea demand is thought to have been affected by the price of Chinese green tea.

Second, we focus on the price elasticity of demand for each green tea. Regarding Japanese demand, from the first to the second period, the absolute value in the short term decreased from 0.927 to 0.740, while the

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4 We cannot obtain production and price data for green tea produced in the United States. However, the Tea Association of the U.S.A (2019) state "Tea growing is expanding in the U.S. (albeit at VERY small volumes)," we therefore do not consider the green tea produced in the United States.

5 Imports of green tea are classified into two types according to HS codes. HS code 090220 is green tea of 3 KG or more, and the HS code 090210 is green tea of 3 KG or less. This paper analyzes both HS codes.

6 In the unit root test, the length of the lag was as follows. In the ADF test, if j represents the lag length that minimizes AIC (Akaike's information criterion), the lag length is set as Min (j+2, 12). In addition, in the PP test, if T represents a sample size, the lag length is set as 4; that is, we round $4(T/100)^{2/9}$ down to the nearest integer value.

7 Standard errors of parameters related to RoW's green tea were estimated using the delta method.

8 We estimate expenditure and price elasticity of demand using the following formula.

Price elasticity of demand $\varepsilon_{ij} = \dfrac{\gamma_{ij} - \beta_i \overline{w}_j}{\overline{w}_i} - \delta_{ij}$

Expenditure elasticity of demand $\varepsilon_i = 1 + \dfrac{\beta_i}{\overline{w}_i}$

However, δ_{ij} is the Kronecker delta, when $i = j$ and $\delta_{ij} = 1$, when $i \neq j$ and $\delta_{ij} = 0$.

Table 1. Results of the unit root test in the first period (Jan. 1994 to Dec. 2005)

Variables	Original series		Difference series		Seasonal difference series	
	ADF test	PP test	ADF test	PP test	ADF test	PP test
	τ	τ	ξ	ξ	μ	μ
w_1	–3.283*	–199.656***	–5.922***	–218.837***	–5.915***	–165.806***
w_2	–3.114	–86.671***	–5.865***	–185.361***	–4.887***	–100.316***
w_3	–2.694	–78.521***	–5.712***	–185.762***	–3.556***	–109.589***
$\ln p_1$	–2.036	–117.551***	–7.180***	–198.676***	–2.452	–129.568***
$\ln p_2$	–2.500	–117.873***	–6.181***	–187.205***	–4.047***	–114.233***
$\ln p_3$	–3.518**	–106.031***	–4.299***	–153.843***	–3.690***	–121.232***
$\ln(p_1/p_2)$	–3.557**	–131.755***	–6.573***	–195.298***	–3.616***	–132.652***
$\ln(p_1/p_3)$	–3.851**	–104.101***	–4.101***	–171.202***	–2.334	–117.278***
$\ln(p_2/p_3)$	–3.771**	–98.670***	–6.761***	–167.210***	–3.846***	–92.697***
$\ln(Y_t/P_t)$	–4.665***	–129.261***	–7.171***	–163.835***	–4.527***	–131.774***

Notes: 1) τ express including intercept, linear time trend, and monthly dummy variables, ξ express including intercept, and monthly dummy variable, μ express including intercept.
2) *, **, and *** indicate that the null hypothesis "there is a unit root" is rejected at the 10%, 5%, and 1% levels, respectively. For the critical values, refer to Davidson and MacKinnon (1993).

Table 2. Results of the unit root test in the second period (Jan. 2006 to Dec. 2017)

Variables	Original series		Difference series		Seasonal difference series	
	ADF test	PP test	ADF test	PP test	ADF test	PP test
	τ	τ	ξ	ξ	μ	μ
w_1	–4.344***	–142.293***	–4.409***	–195.851***	–4.748***	–144.549***
w_2	–3.565**	–79.599***	–5.204***	–174.379***	–3.166**	–101.091***
w_3	–2.225	–123.776***	–4.895***	–187.614***	–3.634***	–146.861***
$\ln p_1$	–1.619	–90.919***	–7.284***	–170.141***	–2.910**	–103.280***
$\ln p_2$	–4.080***	–108.240***	–6.772***	–182.933***	–4.575***	–108.135***
$\ln p_3$	–2.879	–73.078***	–6.164***	–190.023***	–3.118**	–96.446***
$\ln(p_1/p_2)$	–2.490	–89.467***	–4.443***	–165.947***	–2.360	–109.681***
$\ln(p_1/p_3)$	–3.940**	–122.208***	–6.746***	–191.217***	–3.917***	–127.775***
$\ln(p_2/p_3)$	–3.251*	–89.844***	–6.852***	–196.507***	–3.481***	–111.236***
$\ln(Y_t/P_t)$	–4.584**	–93.357***	–4.545***	–168.596***	–4.585***	–80.967***

Note: 1) See Table 1.

long–term absolute value increased slightly from 0.751 to 0.784. By contrast, for Chinese green tea, the absolute value in the short term increased from 0.979 to 1.100, while the absolute value in the long term increased from 0.981 to 1.178. The absolute values have increased together and are both greater than 1 in the second period. Therefore, the response of demand to own price can be considered larger in China than in Japan.

Third, we focus on the green tea expenditure elasticity of demand. For Japanese green tea, from the first to the second period, the short–term expenditure elasticity of demand has increased from 0.849 to 0.975, and the long–term expenditure elasticity of demand has increased from 0.666 to 0.832. For Chinese green tea, the short–term expenditure elasticity of demand has increased from 0.920 to 1.275, and the long–term expenditure elasticity of demand has increased from 1.060 to 1.342. In this way, the expenditure elasticity of demand for Japanese and Chinese green tea have both increased, while the expenditure elasticity of demand for RoW's green tea has decreased from 1.236 to 0.682 in the short term and has also decreased from 1.228 to 0.720 in the long term. Therefore, in the first period, focusing on the demand expansion due to the increased expenditure, RoW's green tea ranks first, Chinese green tea ranks second, and Japanese green tea ranks third. However, the ranking has changed in the second period, Chinese green tea ranks first, Japanese green tea second, and RoW's green tea third.

Fourth, we consider the coefficient of the time trend variable in the share equation, which expresses the change in preference. For Japanese green tea, from the first to the second period, the short–term value of the coefficient has increased from –0.0009 to 0.0024, which is from a negative to a positive value. The long–term value has increased from 0.0002 to 0.0013, while the positive value has increased from the first period to the second period. For Chinese green tea, the short–term

Table 3. Estimation results of the static model

First period (Jan. 1994 to Dec. 2005)				Second period (Jan. 2006 to Dec. 2017)			
	Japan (i=1)	China (i=2)	RoW (i=3)		Japan (i=1)	China (i=2)	RoW (i=3)
α_i	1.330***	0.248	–0.578	α_i	0.720**	–1.485***	1.766***
β_i	–0.096***	0.024	0.072*	β_i	–0.046*	0.137***	–0.091***
γ_{i1}	0.044***			γ_{i1}	0.047***		
γ_{i2}	–0.017	0.017		γ_{i2}	–0.007	–0.016	
γ_{i3}	–0.027**	0.000	0.027	γ_{i3}	–0.040***	0.023	0.016
t_i	0.0002	–0.0007	0.0006	t_i	0.0013***	–0.0001	–0.0012***
d_{i2}	0.058**	–0.058	0.000	d_{i2}	0.056***	–0.036	–0.020
d_{i3}	0.050**	–0.053	0.002	d_{i3}	0.042**	–0.050**	0.007
d_{i4}	0.052**	–0.084*	0.032	d_{i4}	0.070***	–0.063***	–0.007
d_{i5}	0.071***	–0.030	–0.041	d_{i5}	0.057***	–0.031	–0.026
d_{i6}	0.004	0.021	–0.026	d_{i6}	0.109***	–0.038	–0.071***
d_{i7}	0.040	–0.020	–0.021	d_{i7}	0.067***	–0.027	–0.040*
d_{i8}	0.015	–0.027	0.012	d_{i8}	0.043**	0.013	–0.056***
d_{i9}	0.018	–0.002	–0.016	d_{i9}	0.032	–0.001	–0.032
d_{i10}	0.035	–0.020	–0.015	d_{i10}	0.059***	–0.012	–0.048**
d_{i11}	0.061**	–0.016	–0.045	d_{i11}	0.061***	–0.005	–0.055***
d_{i12}	0.022	–0.035	0.013	d_{i12}	0.065***	–0.008	–0.057***
R_2	0.909	0.945	0.923	R_2	0.974	0.979	0.977

Notes: 1) R_2 represents for the coefficient of determination. The R_2 of RoW's share equation is estimated ex post facto using the estimation result.
2) The critical value of the t distribution in the degrees of freedom for the demand system of 257 is 1.651 at the 10% level, 1.969 at the 5% level, and 2.595 at the 1% level. In addition, *, **, and *** indicate that the estimated value is statistically significant at the 10%, 5%, and 1% levels, respectively.

Table 4. Estimation results of the error correction model

First period (Jan. 1994 to Dec. 2005)				Second period (Jan. 2006 to Dec. 2017)			
	Japan (i=1)	China (i=2)	RoW (i=3)		Japan (i=1)	China (i=2)	RoW (i=3)
θ	–0.378***			θ	–0.201***		
λ	–0.508***			λ	–0.557***		
β_i	–0.043***	–0.031	0.075***	β_i	–0.007	0.110***	–0.103***
γ_{i1}	0.008***			γ_{i1}	0.069***		
γ_{i2}	–0.002	–0.004		γ_{i2}	–0.013	0.004	
γ_{i3}	–0.006**	0.007	0.000	γ_{i3}	–0.056***	0.009	0.047***
t_i	–0.0009	–0.0006	0.0014	t_i	0.0024	–0.0012	–0.0012
d_{i2}	0.078***	–0.073***	–0.005	d_{i2}	0.047***	–0.034**	–0.013
d_{i3}	0.088***	–0.073**	–0.015	d_{i3}	0.041**	–0.056***	0.015
d_{i4}	0.079***	–0.099**	0.020	d_{i4}	0.063***	–0.069***	0.006
d_{i5}	0.093***	–0.051	–0.041	d_{i5}	0.053**	–0.039	–0.015
d_{i6}	0.038	0.017	–0.056	d_{i6}	0.101***	–0.038	–0.063***
d_{i7}	0.056*	–0.003	–0.053	d_{i7}	0.068***	–0.030	–0.038*
d_{i8}	0.047	–0.033	–0.014	d_{i8}	0.036	0.013	–0.050**
d_{i9}	0.050*	–0.018	–0.032	d_{i9}	0.018	0.009	–0.027
d_{i10}	0.067***	–0.025	–0.042	d_{i10}	0.043**	0.001	–0.044**
d_{i11}	0.095***	–0.022	–0.073**	d_{i11}	0.050***	0.005	–0.055***
d_{i12}	0.056***	–0.033	–0.024	d_{i12}	0.051***	0.005	–0.056***
R_2	0.702	0.428	0.389	R_2	0.644	0.461	0.627

Notes: 1) R_2 represents for the coefficient of determination. The R_2 of RoW's share equation is estimated ex post facto using the estimation result.
2) The critical value of the t distribution in the degrees of freedom for the demand system of 253 is 1.651 at the 10% level, 1.969 at the 5% level, and 2.595 at the 1% level. In addition, *, **, and *** indicate that the estimated value is statistically significant at the 10%, 5%, and 1% levels, respectively.

Table 5. The estimated values of the price elasticity and green tea expenditure of demand

	First period			Second period		
Price \ Quantity demanded	The short–term			The short–term		
	Japan	China	RoW	Japan	China	RoW
Japan	–0.927***	0.017	–0.087***	–0.740***	–0.108***	–0.086**
China	0.052**	–0.979***	–0.073*	–0.038	–1.100***	0.156***
RoW	0.027	0.042*	–1.076***	–0.197***	–0.067	–0.752***
Expenditure	0.849***	0.920***	1.236***	0.975***	1.275***	0.682***
Price \ Quantity demanded	The long–term			The long–term		
	Japan	China	RoW	Japan	China	RoW
Japan	–0.751***	–0.060	–0.151***	–0.784***	–0.111***	–0.045
China	0.073	–0.981***	–0.090	0.042	–1.178***	0.184***
RoW	0.012	–0.019	–0.987***	–0.090	–0.053	–0.859***
Expenditure	0.666***	1.060***	1.228***	0.832***	1.342***	0.720***

Note: The critical value of the t distribution in the degrees of freedom for the demand system of 253/257 is 1.651 at the 10% level, 1.969 at the 5% level, and 2.595 at the 1% level. In addition, *, **, and *** indicate that the estimated value is statistically significant at the 10%, 5%, and 1% levels, respectively.

value of the coefficient has decreased from –0.0006 to –0.0012, and the long–term value has increased from –0.0007 to –0.0001, which is a negative value that becomes smaller from the first to the second period. By contrast, focusing on the RoW's green tea, the short–term value has decreased from 0.0014 to –0.0012, and long–term value has decreased from 0.0006 to –0.0012. That is, Japanese and Chinese green tea can be seen to have become more favorable, and RoW's green tea is no longer preferred.

Table 6 shows the descriptive statistics for each green tea. Green tea for raw and processed materials or business is mainly imported from China, as the prices are low and the import volumes are large. By contrast, although the import quantity of Japanese green tea is small, its price is high because it is considered to be of high quality. That is, according to the change in the demand structure, in the second period, high–quality Japanese green tea became more acceptable to Americans.

CONTRIBUTION ANALYSIS OF SHARE CHANGE OF JAPANESE GREEN TEA IMPORT VALUE

Analysis method

Based on the estimation results of the previous section, we clarify the degree of contribution of each factor for the change in the import value share of Japanese green tea. The estimation method is as follows.

First, the share equation of Japanese green tea (i = 1) is expressed as follows.

$$w_{1t} = \alpha_1 + \beta_1 \ln\left(\frac{Y_t}{P_t}\right) + \sum_{j=1}^{3}\gamma_{1j}\ln p_{jt} + t_1 TR_t + \sum_{s=2}^{12} d_{1s}DM_s + e_{1t} \quad (5)$$

Here, by partially differentiating equation (5) with respect to the time trend variable TR_t, it is possible to obtain the following equation.

$$\frac{\partial w_{1t}}{\partial TR_t} = \beta_1 \frac{\partial (Y_t/P_t)/(Y_t/P_t)}{\partial TR_t} + \gamma_{11}\frac{\partial p_{1t}/p_{1t}}{\partial TR_t} + \gamma_{12}\frac{\partial p_{2t}/p_{2t}}{\partial TR_t} + \gamma_{13}\frac{\partial p_{3t}/p_{3t}}{\partial TR_t} + t_1 \quad (6)$$

Here, $\frac{\partial w_{1t}}{\partial TR_t}$ is the amount of change in import value share per period, $\beta_1 \frac{\partial (Y_t/P_t)/(Y_t/P_t)}{\partial TR_t}$ is the amount of change in import value share per period due to the change in Y_t/P_t per period, $\gamma_{jt}\frac{\partial p_{jt}/p_{jt}}{\partial TR_t}$ represents the amount of change in import value share per period due to the change in p_{jt} per period. That is, the amount of change in import value share of Japanese green tea can be considered as broken down into five factors: expenditure (Y_t/P_t), Japanese green tea price, Chinese green tea price, and RoW's green tea price, and the change of preference.

The parameters, β_1, γ_{11}, γ_{12}, γ_{13}, and t_1 are estimated using equation (1) in the long term. $\frac{\partial (Y_t/P_t)/(Y_t/P_t)}{\partial TR_t}$ and $\frac{\partial p_{jt}/p_{jt}}{\partial TR_t}$ are estimated by the following equations.

$$\ln\left(\frac{Y_t}{P_t}\right) = \delta_a + \omega_a TR_t + \sum_{s=2}^{12} d_{as}DM_s + \eta_{at} \quad (7)$$

$$\ln p_{jt} = \delta_j + \omega_j TR_t + \sum_{s=2}^{12} d_{js}DM_s + \eta_{jt} \quad j = 1, 2, 3 \quad (8)$$

It can be assumed that $\frac{\partial (Y_t/P_t)/(Y_t/P_t)}{\partial TR_t} = \omega_a$ and $\frac{\partial p_{jt}/p_{jt}}{\partial TR_t} = \omega_j$. In the estimation of equations (7) and (8), we assume that there is a first–order autocorrelation in the error term and estimate using the maximum likelihood method.

Table 6. The descriptive statistics of import quantity and price (Unit: tons, the US dollar/kg)

	First period (Jan. 1994 to Dec. 2005)			Second period (Jan. 2006 to Dec. 2017)		
Variable	mean	minimum value	maximum value	mean	minimum value	maximum value
Import quantity from Japan	28.47	3.06	119.91	119.14	18.73	344.55
Import quantity from China	480.83	103.07	1120.23	875.99	207.79	2033.60
Import quantity from RoW	148.47	3.38	532.37	442.63	223.97	838.88
Real import price from Japan	6.17	1.74	10.99	8.93	2.59	16.98
Real import price from China	0.93	0.38	2.36	1.76	0.80	2.89
Real import price from RoW	2.85	0.82	11.19	2.57	1.42	4.35

Source: Author estimates based on United States Department of Agriculture (2018) and United States Department of Labor (2018).

Table 7. Results of estimation of contribution analysis

	First period (Jan. 1994 to Dec. 2005)		Second period (Jan. 2006 to Dec. 2017)	
Factors	Estimated value of ω	Impact of each factor (Conversion to %)	Estimated value of ω	Impact of each factor (Conversion to %)
Japanese price	–0.0061	–0.03% (–3.83%)	0.0020	0.01% (1.33%)
Chinese price	0.0052	–0.01% (–1.26%)	0.0049	–0.00% (–0.49%)
RoW's price	0.0004	–0.00% (–0.14%)	–0.0032	0.01% (1.83%)
Expenditure (Y_t/P_t)	0.0104	–0.10% (–14.42%)	0.0011	–0.01% (–0.75%)
Trend variable (Change in preference)	0.0002	0.02% (2.19%)	0.0013	0.13% (18.80%)
Total impact		–0.12% (–17.46%)		0.14% (20.73%)

Notes: 1) For the effect of each factor, the upper value is the effect of per month (per period), values in parentheses are the sum of the effects of 12 years (144 periods).
2) The total impact is the sum of the effects of each factor.

Analysis result

The analysis results of the contribution degree of each factor are presented in Table 7. Looking at the total impact, which is the sum of each factor, we find that the share of Japanese imports decreased by 17.46% in the first period[9]. The factor that most affected this decrease was the increase in green tea expenditure (Y_t/P_t) in the United States, which has decreased 14.42% over 12 years. Although expenditure on imported green tea increased, the expenditure elasticity of demand for Japanese green tea was relatively lower than that of Chinese and RoW, so the rate of increase in Japanese demand is relatively lower than the others. As a result, the share of Japanese imports decreased. That is, it can be said that the largest factor in the decline in Japanese green tea import value share in the first period was the increase in green tea expenditure in the United States and the low expenditure elasticity of demand for Japanese green tea.

Looking at the total impact in the second period, the share of Japanese imports increased by 20.73% in 12 years. The factor that most affected this increase is the change in preference in the United States, which increased by 18.80% over the past 12 years. This indicates that the degree of change in the preference that Japanese green tea is preferred is strengthened by the change in demand structure. That is, the largest factor that increased the share of Japanese imports in the second period was due to changes in preference.

As previously mentioned, in response to the change in the share of imported Japanese green tea, the influence of the price is relatively small, the expenditure was the largest factor in the first period, and the change in the preference was the largest factor in the second period.

SUMMARY

The aim of this study is to analyze the factors causing the expansion of Japanese green tea exports to the United States from 2006 onwards. Specifically, green teas imported into the United States are classified into three items: Japanese, Chinese, and RoW green tea. The analysis period is from January 1994 to December 2005 (the first period) and January 2006 to December 2017 (the second period), and the green tea demand structure is estimated. Next, based on the aforementioned results, we clarify to what extent the factors such as changes in the price or preference have contributed to changes in the import value share of Japanese green tea.

The main analysis results are as follows.

First, Japanese green tea demand is differentiated from that of Chinese and RoW's green tea. In addition, the absolute value of the price and expenditure elasticity of demand for Japanese green tea is smaller than that for Chinese green tea.

[9] The 12–year impact of each factor was calculated by multiplying the change in the share of import value per month by 144 (12 years = 144 months).

Second, Japanese green tea has become more popular among Americans in the second period.

Third, the decrease in the value share of Japanese green tea imports in the first period is due to the increase in expenditure on green tea in the United States and the low expenditure elasticity of demand for Japanese green tea. The increase in the value share of Japanese green tea imports in the second period is due to the change in preference.

Finally, future issues are as follows. First, in analyzing green tea trade, it is necessary to consider factors on the supply side as well as imports. Furthermore, for green tea exports, it is necessary to meet the "pesticide residual standard" of the importing country. Since this standard has become stricter in recent years, it is also necessary to analyze this influence. By overcoming these problems, it is assumed that more sophisticated analysis will be possible regarding green tea trade.

AUTHOR CONTRIBUTIONS

Likun LYU designed the study, collected and analyzed the data, and wrote the paper, Kohya TAKAHASHI assisted in designing the study, analyzing the data and writing the paper, and Koshi MAEDA designed and supervised the whole of study.

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