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Why has US sorghum lost the market share in the Japanese market?

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Abstract

About 20 years ago, the United States had the largest market share of sorghum in the Japanese market. However, in recent years, Australia's share of the same market has been constantly growing and has now claimed the top position. A possible explanation suggests that US sorghum lost price competitiveness in the Japanese market. However, the analysis of the ratio of US vs Australian sorghum prices in Japan, shows that there has been little change over the past 20 years. This paper investigates whether prices of Australian sorghum has affected the demand for US sorghum in the Japanese market. If it is not the case, the quality differential between those two grains might be a factor which can explain the decline of US sorghum market share in Japan. A modified Armington model was used for this analysis. This model used an ITSUR (Iterated Seemingly unrelated regression) method to estimate the effects of prices of five grains (US sorghum, Australian sorghum, US corn, sorghum imported from the rest of world) and Japanese farms' feeding expenditure on the demands of those five grains.

Introduction

Sorghum is mainly used for feeding, and is a good substitute for corn. Livestock feeders perceive that sorghum is inferior to corn due to its quality, and that sorghum is grain with little differentiation.

Japan produces little sorghum because the productivity of making sorghum is relatively low compared to other countries and other industries in Japan. But Japan imports a high volume of sorghum due to the existence of a somewhat large cattle feeding industry.

The United States produces and exports a large amount of sorghum, mainly because the United States has a high productivity of sorghum production compared to other countries, and its domestic consumption is low. Therefore, prices of US sorghum can be kept relatively low in world markets. Therefore, the market share of US sorghum could be maintained in international markets by keeping the price relatively low. However, US sorghum is losing its share in the Japanese sorghum market. The United States held the largest share in the Japanese sorghum market for 20 years, but in recent years, Australia's share of the same market has been constantly growing and has now claimed the top position despite the fact that US sorghum is cheaper.

This paper investigates potential causes of US sorghum declining its market share in the Japanese market. For that purpose, the own and cross price elasticities of US sorghum were checked. If the cross price elasticity of US sorghum with Australian sorghum is close to zero, changes of the price difference between these goods are not an important factor for Australian sorghum winning over US sorghum with respect to market share in the Japanese market.

This paper is composed of five sections, 1) Graph Analysis, 2) Previous Studies, 3) Conceptual Framework, 4) Empirical Framework, 5) Analysis Result, and 6) Conclusion.

Graph Analysis

Description of the Sorghum Market in Japan

Originally, sorghum has four types - grain sorghum, sweet sorghum, broom sorghum, and grass sorghum. The sorghum studied in this research is grain sorghum, which is used for feeding livestock. Sorghum is actually edible, but it is not suitable for a human diet.

Table 1

Quantity of US Sorghum Imports by Country (thousand tons)

	2013	2012	2011
Chile	250	150	404
China	4,161	631	84
Colombia	104	591	592
Japan	1,003	1,897	1,481
Mexico	162	1,789	1,369

*The data source is the USDA

Table 1 shows the quantity of US sorghum imports by country for the last 3 years. Japan has been the second largest importer of US sorghum in 2013, and the largest importer in 2011 and 2012. Major exporters of sorghum to Japan are Australia, United States, Argentina and China. The amount of domestic production of sorghum is very small in Japan.

Table 2

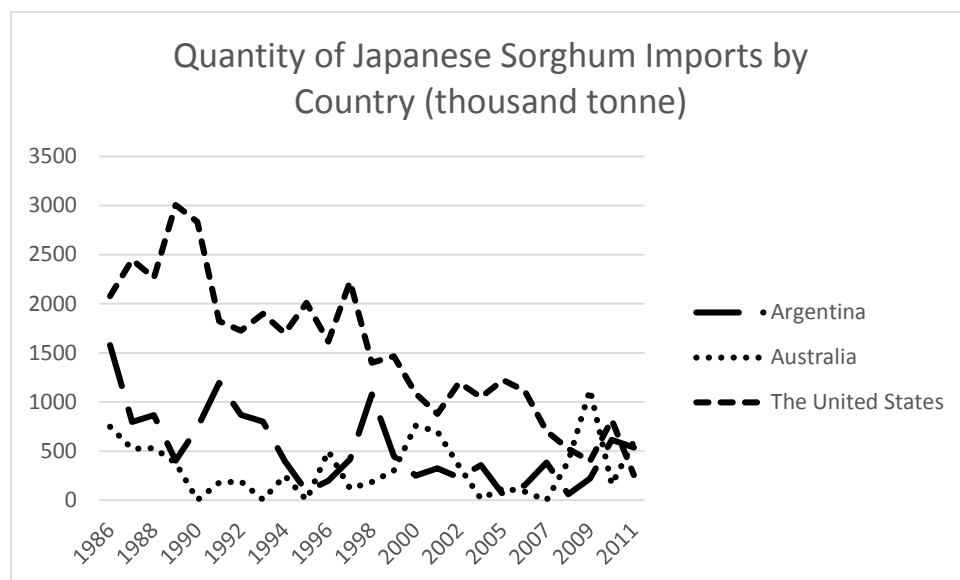
Production of Livestock and Poultry (thousand tons)

	Pork Meat	Beef Meat	Broiler Meat
China	53,800	5637	13500
Brazil	3,370	9600	12770
Japan	1,305	495	1280
Mexico	1,270	1775	3002
United States	10,508	11702	16958

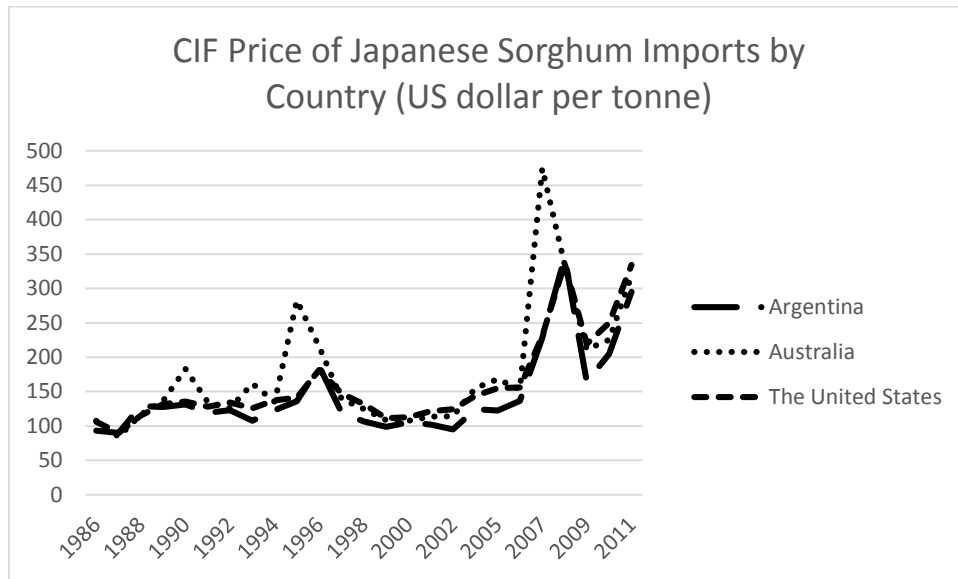
*The data source is the USDA

Sorghum is mainly for feeding livestock in Japan. Table 2 shows the production of livestock and poultry by country. The size of the production of livestock and poultry in Japan is much less than those in United States, but is nearly equal to those in Mexico. Therefore, Japan has a relatively large demand for sorghum. The Japanese tariff rate on imported sorghum is 5%.

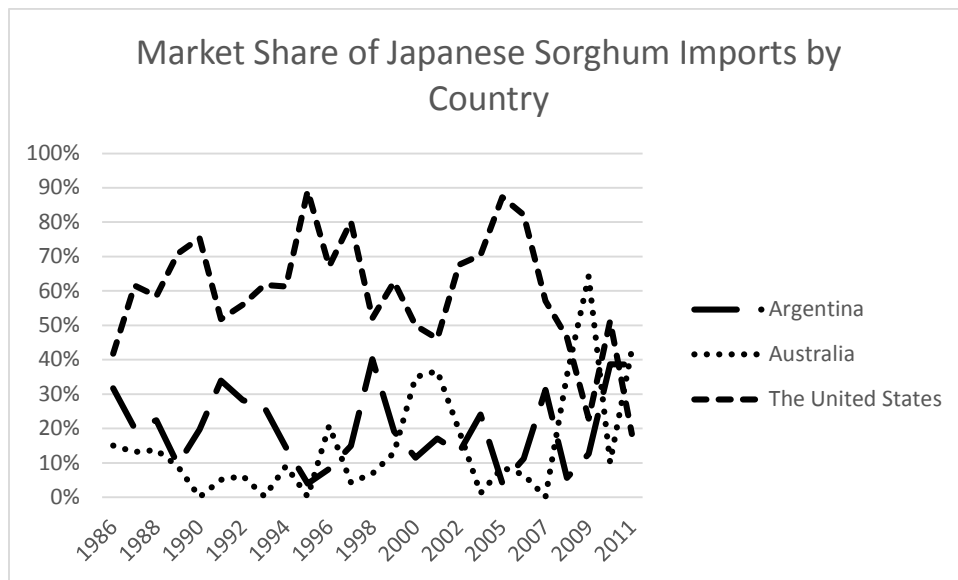
Graph 1



*The data source of this graph is FAO

Graph 2

*The data source of this graph is FAO

Graph 3

*The data source of this graph is FAO

As indicated in the introduction, the market share of US sorghum has decreased over the past 20 years in the Japanese market while the market share of Australian sorghum has increased. Graph 3 clearly shows this trend. However, Graph 2 shows that there has been little change in the difference between the CIF prices of Australian and US sorghum over the past 20 years.

Previous Studies

An estimation of the cross price elasticity between goods from different origins – for example, Chinese wheat and US wheat- is not the same as an estimation of the cross price elasticity between different goods - for example, an apple and a computer. The reason is that there is less differential in the characteristics of goods from different origins than in those of different goods. Though, some goods produced in Country A may have better quality than the same goods produced in Country B, and those goods are basically used for the same purpose.

Hence, while the expenditure share of different goods like an apple and a computer are decided in the first budget, the allocation of the expenditure share of the goods from different origins are decided in the second budget. We usually choose the consumption amount of an apple and a computer under our income constraint at first, and then, we decide the consumption amount of an apple made in US or Mexico under the budget constraint of our apple consumption allocated in the first stage.

Armington (1969) developed an equation model to estimate the cross price elasticity of goods from different origins, which was derived from the second stage of a two stage CES utility function. This model has three assumptions, homotheticity, single elasticity, and separability. The assumption of the homotheticity is that the change in the expenditure of some goods does not alter the share of the goods from each supplier. The assumption of the single elasticity is that the product from each origin has the same price elasticity. The assumption of separability is that the marginal rate of the substitution between goods from different origins is independent of the consumption quantity of the other goods in the first budget.

Using the model coined by Armington, Kenneth and Roland-Holst (1992) estimated the cross price elasticity of domestic products with the price of imported products in 163 sectors in the United States. Those sectors included the prepared feed production sector, which is material for feeding livestock. The estimated cross price elasticity of domestic prepared feed with the price of imported prepared feed in their research is 1.24, and the t-ratio of this parameter was 6.24.

Many researchers suspected that two assumptions of Armington model, homotheticity and single elasticity, were unrealistic since goods produced in different country must have different qualities. A study conducted by Johnson (1977) suggests that wheat, tobacco, and cotton are not homogenous, and Johnson concludes that goods from different locations are differentiated by quality, contractual obligation, and location of processing facilities. Capel (1966) found out that there is a difference among the cross price elasticity of US Flue-cured tobacco with the prices of those made in United Kingdom, West Germany, and Benelux, and rejected the assumption of single elasticity. If goods are non-homogenous, the assumption of the hometheticity is not appropriate. Because there is a quality difference among goods from different origins, goods made in location A might be normal goods and the same goods made in location B might be inferior goods. Therefore, the allocation of the expenditure on goods from different origins cannot be invariant regardless of the amount of the total expenditure. Ito, Chen, and Peterson (1990) claim that data does not support the two assumptions, and estimations based on those assumptions may be biased.

Ito, Chen and Peterson modified the Armington model, and allowed non-homotheticity and different price elasticity for each good in the group. Based on this modified model, they estimated the price elasticity of exported rice from each country in the world market and the elasticity of the expenditure on rice. Also, they tested the appropriateness of the hometheticity and the single price elasticity assumptions in the restricted model, and rejected it.

Yang and Koo (1993) modified the model the same way, and developed “the generalized Armington trade model”. They estimated the price elasticity of imported red meats from five meat exporting countries into the Japanese market and the expenditure elasticity.

Alston, Carter and Green (1990) modified the model the same way. While Ito, Chen, and Peterson and Yang and Koo neglected the cross price elasticity of products from different countries, Alston, Carter, and Green added it in their modified model. They estimated the cross price elasticity of wheat from different countries in five major importing countries and the cross price elasticity of the cotton from different countries in five major importing countries.

The econometric method used for the estimation of the cross price elasticity is usually a SUR (Seemingly Unrelated Regression). Ronald (1987), who estimated the cross price elasticity of US cotton imports with the imported cottons from other countries in the several countries' cotton markets, suggested that there are contemporaneous correlations among demands of importing countries. Unobserved factors in one country may affect the demand of the own country and demands of other countries as well. Therefore, the result of an OLS regression may not be efficient.

As far as we know, no research estimating the cross price elasticity between sorghum, crop and other prepared feeds from different origins based on a modified Armington model has been conducted.

Conceptual Framework

Elasticities of imported agricultural good demands are usually estimated from two-stage utility maximization. Armington assume that consumers allocate their consumption within the budget for maximizing the utility. In this research, Japanese farmers allocate their purchase of capital, labor and intermediate goods for maximizing the profit of their poultry production. Hence, as is proposed by Davis and Jasen (1994), the equation in the first stage needs to be a profit function. The profit function in the first stage is the following function.

$$\pi = p * q(x_1, x_2, , x_n) - \sum_{i=1}^N w_i * x_i \quad (1)$$

In the function (1), the inputs of the poultry production, which includes feeding grain, are x_i , and the prices of the inputs are w_i . The optimal consumption of feeding grain by Japanese farmers are solved from the derivative of the function (1) with x_g . Once we get the optimal consumption of feeding grain, the budget for feeding grain is found out since w_g is a known price here. w_g is assumed to be the geometric weighted average price of feeding grains.

In reality, Japanese farmers allocate the consumption of each feeding grain for maximizing the total productivity of all feeding grains, given the budget decided in the first stage. Therefore, it is appropriate to assume that the optimal consumption of all feeding grains is the Marshallian conditional demand from the first stage. However, as Davis and Kruse (1993) claimed, the equation to estimate elasticity from the conditional Marshallian demand is nonlinear and complicated. For that reason, we followed the approach of the traditional Armington model, and it is assumed that optimal consumption of each feeding grain in the second stage is set for minimizing cost given the estimated output from feeding grain in the first stage.

This research deviated from the traditional Armington model approach. Armington assumes that different goods belong to different groups in the last stage, and each group in the last stage is composed of the same goods imported from different countries. But, in this research, different goods imported from different countries belong to a group in the last stage. Since Japanese farmers decide how much they buy of US sorghum and Australian corn from the same budget, US sorghum and Australian corn need to belong to the same goods group in the last stage.

$$q'(x_g) = \frac{w_g}{p_g} \quad (2)$$

$$\varphi x_g = \frac{w_g}{p_g} * x_g^* \quad (3)$$

$$\text{Min } \sum_{j=1}^J p_j x_{gj} \quad \text{st } \varphi x_g = (\sum_{j=1}^J b_j x_{gj}^\theta)^{1/\theta} \quad 0 < \theta < 1 \quad (4)$$

In order to estimate the output from feeding grain, productivity of feeding grain needs to be estimated. The first derivative of the profit function (1) with respect to x_g , which is equation (2), is the function to estimate productivity of feeding grain. Thus, equation (3) estimates the output from the optimum amount of feeding grain. As is assumed by Armington model, the function of output from feeding grain is a CES production function. Equation (4) indicates that the optimum quantity of each grain is solved from minimizing the expenditure of feeding grain, given the output from feeding grain set in the first stage.

$$p_{gj} x_{gj} / p_g x_g = b_g^\sigma (p_{gj} / p_g)^{1-\sigma} \quad (5)$$

$$\ln \left(\frac{p_{gj} x_{gj}}{p_g x_g} \right) = \sigma \ln(b_g) + (1 - \sigma) \ln \left(\frac{p_{gj}}{p_g} \right) \quad (6)$$

Armington derived equation (5) from equation (4), which represents the expenditure share of each feeding grain. The variable x_g is the Hicksian demand of the goods group of the feeding grains set in the first stage. Equation (6) is the log transformed of equation (5). As suggested by many researchers,

Equation (6) has some problems. First, the expenditure share of each good has the same own price elasticity $(1-\sigma)$. Second, the variables of the prices of the other goods belonging to the same goods group are not taken into account in the equation.

$$\ln(p_{gj}x_{gj}/p_gx_g) = \sigma\ln(b_j) + \sum_{j=1}^J(1 - \sigma_j)\ln(p_{gj}/p_g) \quad (7)$$

Equation (7) can solve these problems. This equation was derived from equation (5) by Yang and Koo. Yang and Koo relaxed the assumption of single price elasticity, and allowed the effect of the prices of the other goods on the expenditure share of each good.

There is one more problem in equation (7). The effect of the total expenditure in the second stage on the consumption of each grain is not considered there. In the Armington model, it is assumed that the total expenditure influences the consumption of each good uniformly, and that the change of the total expenditure has no effect on the expenditure share of each good. However, this assumption is not realistic.

$$\ln(p_{gj}x_{sj}) = \beta_j\ln(p_gx_g) \quad (8)$$

$$\ln\left(\frac{p_{gj}x_{gj}}{p_gx_g}\right) = \sigma\ln(b_j) + 2/(1 + \beta_j)\ln p_gx_g + \sum_{j=1}^J(1 - \sigma_j)\ln(p_{gj}/p_g) \quad (9)$$

Yang and Koo set up equation (7), and show the relationship between the total expenditure and the expenditure of each good in this equation. They made up equation (9) by integrating equation (8) into equation (7).

$$\ln(x_{gj}) = \sigma\ln(b_j) + \ln(x_g) + \frac{2}{(1+\beta_j)}\ln p_gx_g + \sum_{i \neq j}^J(1 - \sigma_i)\ln\left(\frac{p_{gi}}{p_s}\right) - \sigma_j\ln\left(\frac{p_{gj}}{p_g}\right) \quad (10)$$

Equation (9) estimates the own and cross price elasticities of each expenditure share. This research tries to estimate the cross and own price elasticities of demand of each grain. Equation (10) was transformed from the equation (9), and can estimate these elasticities.

The Empirical Framework

Data

The data set used in this analysis is the monthly data about Japanese imports of US sorghum and corn, Australian sorghum, corn and sorghum from the rest of world (ROW), and the other grain for feeding (millet, oat, and barely) from 1999 to 2013. The number of the observations is 113. The prices of these grains are in Japanese yen. The data was obtained from the trade statistics database in the Japanese Trade Custom agent.

Econometrics Model

$$\ln Q_{it} = \alpha_i + \varphi_i \ln Q_t + \sum_j \beta_{ij} \ln \frac{Price_{jt}}{PriceIndex_t} + \gamma_i \ln \frac{TotalExpenditure_t}{PriceIndex_t} + \delta_i \ln Q_{it-1} + \sum_i \tau_i D_{ti} \quad (11)$$

$$\text{Cosntraint conditions} \quad \beta_{ij} = \beta_{ji} \text{ (Symentry)} \quad \varphi_i = 1$$

An ITSUR (Iterated Seemingly Unrelated Regression) was done on the data, and there are five linear equations in this econometric analysis. The regression equations are equation (11), and the variables of Q_i are US sorghum, Australian sorghum, US corn, corn and sorghum from the rest of world. This equation was derived from equation (10). The constraint that the parameter of $\ln Q_i$ is one needs to be added since the coefficient of the $\ln Q_t$ is one in equation (10). The Q_{it} is the Hicksian demand of each grain, and therefore, the cross price elasticity of each pair of feeding grains is symmetric. Hence, we need to add the constraint that $\beta_{ij} = \beta_{ji}$.

The one-month lag import quantity was added on equation (11). Ayuk and Ruppel (1988) pointed out that import shipment often lag sales contract. Some part of the last month demand of grain

may be the current import quantity of the grain. Therefore, the last month export quantity will affect the current import quantity.

D_{it} is a monthly dummy for controlling seasonal effect. Heien and Pick (1991) conducted an analysis on the demand of soybean using quarterly data, and they put quarterly dummies in the regression to capture seasonal effects. Following their research, this research used monthly data for the demand analysis of feeding grain, and therefore, monthly dummies needs to be added in the equations.

The Research Result

The econometrics model in this analysis is a double-log model, and the parameter values of the price coefficients indicate the degree of elasticity. The result suggests that the own price elasticity of US sorghum is more than 2, and it seems to be overestimated. It seems that the estimation of this model has problems. We identified and fixed these problems. First, influential outliers were checked and deleted. We did a regression of each grain separately, and outliers were identified based on the Cook's distance values of the observations. 30 observations were identified as an outlier, and dropped.

Then, the autocorrelation of the residuals were checked based on the Godfrey test, and we found that the residuals of all the regressions in this model were correlated. Therefore, the first and the second lag of the residuals were added as an independent variable in the regressions. But, only the first and the second lag of the residual in the Australian sorghum regression and the first lag of the residual in US sorghum regression are significant. So, we kept only these residuals. Table1 shows the result of the modified regression.

Table 1

	Australian Sorghum	US Sorghum	US Corn	ROW Sorghum
Intercept	-11.08(4.96)**	-19.33(3.7)***	-2.35(0.82)***	-11.23(4.17)***
Australian Sorghum	0.09(1.02)	0.39(0.52)	0.09(0.07)	0.6(0.65)
US Sorghum	0.39(0.52)	-1.1(0.53)**	-0.04(0.13)	-0.2(0.38)
US Corn	0.09(0.07)	-0.04(0.13)	-0.17(0.15)	0.14(0.07)**
ROW Sorghum	0.6(0.65)	-0.2(0.38)	0.14(0.07)**	0.02(0.69)
Other Grain	-1.17(0.68)*	0.96(0.29)***	-0.02(0.04)	-0.56(0.49)
Total Expenditure	0.6(0.67)	1.16(0.54)**	-0.49(0.06)***	-0.27(0.55)
Lagged Quantity	0.25(0.08)***	0.7(0.05)***	0.41(0.06)***	0.89(0.07)***
Dummy Jan	0.01(0.3)	-0.09(0.28)	-0.08(0.03)**	0.06(0.36)
Dummy Feb	-0.2(0.28)	0.22(0.23)	-0.12(0.03)***	0.13(0.33)
Dummy Mar	-0.15(0.34)	0.14(0.26)	-0.02(0.03)	-0.29(0.38)
Dummy Apr	0.32(0.34)	0.17(0.25)	-0.05(0.03)*	-0.03(0.37)
Dummy May	0.45(0.35)	-0.31(0.25)	-0.09(0.03)***	0.32(0.38)
Dummy Jun	1.27(0.38)***	-0.45(0.27)*	-0.12(0.03)***	0.73(0.41)*
Dummy Jul	0.43(0.32)	-0.52(0.23)**	-0.07(0.03)**	0.44(0.34)
Dummy Aug	0.96(0.32)***	-0.22(0.23)	-0.06(0.03)**	0.27(0.34)
Dummy Sep	0.71(0.34)**	0.06(0.25)	-0.1(0.03)***	0.34(0.35)
Dummy Oct	0.59(0.33)*	0.21(0.24)	-0.01(0.03)	0.21(0.36)
Dummy Nov	0.44(0.31)	0.46(0.27)*	-0.05(0.03)	-0.06(0.35)
R ²	0.62	0.88	0.83	0.76

According to the result of this regression analysis, only the own price elasticity of US sorghum may be negatively significant, and the demand of US sorghum may be slightly price elastic. Grain prices in this analysis here is a nominal price divided by the price index of these grains. Therefore the price changes of the grains is a relative price change. A change of the relative price of US sorghum may have affected the demand of US sorghum, but relative price changes of corn and Australian sorghum may not have affected the demands of Australian sorghum and corn. It implies that Japanese farmers may be loyal to corn and Australian sorghum.

The result tells us that the cross price elasticity between US sorghum and corn and the cross price elasticity between US sorghum and Australian sorghum may not be significant. Corn and

Australian sorghum may not be price substitute for US sorghum in the Japanese grain market. A decrease in the relative prices of Australian sorghum and corn may not affect the demand of US sorghum.

According to the result, the income elasticity of US sorghum is negatively significant, and the income elasticity of corn is positively significant. The income elasticity of Australian sorghum is significant. The real expenditure has been on a downward trend over 10 years. It may decrease the consumption of US sorghum, and increase the demand of corn in the Japanese market. But, it may not affect the demand of Australian sorghum. Due to the contraction of the real budget for feeding grain, Japanese farmers may have decreased the consumption of US sorghum, but have increased the consumption of corn.

The nominal budget of Japanese farmers for feeding grain has increased over that time, but the real budget, which is adjusted by the price index of feeding grain, has declined since this price index has an upward trend. Therefore, the upward trend of the price index causes Japanese farmer to switch from US sorghum to corn. On the other hand, since the demand of Australian sorghum may not be sensitive to the change of Japanese farmers' real budget of feeding grain, this upward trend has not affected the demand of Australian sorghum in the Japanese grain market.

Conclusion

According to the result of this analysis, US sorghum and Australian sorghum are not price substitutes in the Japanese market. The price differential between these grains may not matter to the shares of US sorghum and Australian sorghum. This result shows clear evidence why US sorghum has lost its market share in the Japanese grain market. An increase of the general price of feeding grain may cause a change of the pattern of Japanese farmer's consumption of feeding grain. They have decreased their consumption of US sorghum, and increased their consumption of Corn. It suggests that Japanese

farmers may feel that the quality of US sorghum does not worth its price when the prices of all grains rise up, and they discontinue their purchase of US sorghum and consume corn instead. On the other hand, Japanese farmers continue the purchase of Australian sorghum at that time. Therefore, the quality differential of US sorghum and Australian sorghum can explain the loss of the market share of US sorghum in the Japanese market.

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