An Econometric Analysis of Beef Demand in Japan

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日本の牛肉需要に関する計量分析

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日本の家計では高度経済成長期に畜産物の家計消費量が増加し、この時期の20年間で消費量は約5倍となった。この要因として考えられるのは、家計所得の増加による増加分が半分の約2.5倍、残りの半分は、価格の低下、嗜好の亢進、官製食育によるものである。その後、70年代後半に日本経済が低成長に転換すると、畜産物の家計需要量も停滞傾向に転じた。畜産物の中での主要品目である牛肉について近年の国内需要についてみると、特徴的なのは、2003年12月に米国で発生したBSEの影響で豪州産が米国産に代替したが、数量ベースで輸入牛肉は39%減少した点である。一方で、国産牛肉の消費量は増加しなかった。そこで、BSE以後の牛肉の国内需要の実態を明らかにするため、牛肉を対象とした需要体系分析を行った。その結果、国産牛肉は特に品質が隣接する畜種間でこうした「つぶし合い」の効果が大きく、一方、輸入牛肉はほとんど影響を受けていないことが明らかになった。

Key words: beef demand, econometric analysis, LA/AIDS, Japan

1. Outline of Household Expenditure on Livestock Products

During the period of Japan’s high economic growth (from 1950s to early 1970s), consumption of livestock products by Japanese households increased nearly fivefold.

Fig. 1 shows the household livestock consumption trend in Japan from 1951 to 2015. Since household real food expenditure has increased by 138.7% and elasticity of livestock products expenditure was 1.768 (Tanı and Kusakari, 2013), 244.7% (=138.7%×1.768) of the increment in consumption of livestock can be attributed to the increase in household income. The remaining half (250%) was due to declining prices, increasing preferences, and governmental dietary education (Kusakari, 2011). The figure further shows that, Following the slow economic growth since the second half of 1970s, household demand for livestock products also became stagnant.

2. Domestic Demand for Beef in Recent Years

Beef is the primary item included in domestic demand for livestock products. Fig. 2 shows the imported and domestic beef supply quantities in recent years. Overall, the quantity of imported beef has decreased by 39% during this period. In fact, following the prevalence of bovine spongiform encephalopathy (BSE) in the United States in December 2003, the import from US was largely replaced by Australian produce. Yet, domestic beef consumption did not increase in response to the overall decline in import.

Therefore, we perform a demand system analysis for beef and clarify domestic demand for beef after BSE. As shown in Fig. 3, the demand for beef in recent
years has decreased the proportion of homemade meals, and business use of beef for consumption has become important. Hence, besides analyzing household demand using the “Family Income and Expenditure Survey”, it is also necessary to analyze the demand by types of beef cattle used in business.

Matsuda (2014) and Takahashi and Maeda (2016) are the previous studies on the recent beef demand in Japan. To analyze the impacts of the Trans-Pacific Partnership (TPP) agreement on domestic beef production, the linear approximate almost ideal demand system (LA/AIDS) is estimated after dealing with nonstationary time series data. It is a feature of these studies that cross-price elasticities are the negative values, and the results show the complementary goods among cattle species. As Takahashi and Maeda (2016) pointed out, the customers empirically demand as the substitute goods among cattle species. Therefore, these results contradict the reality. The originality and novelty of this paper is therefore, while following the method of previous studies, we estimate more realistic expenditure and price elasticities.

3. Empirical Analysis

(1) Analysis Data

Beef is divided into the following four items: 1) Wagyu beef, 2) hybrid beef, 3) dairy steer beef, and 4) imported beef. We estimate LA/AIDS using annual Japanese data from 2004 to 2015 for four items of beef, providing a total of 12 samples. The demand is the estimated turnover amount based the cut meat, and the prices are evaluated at the wholesale prices.

The data for the domestic beef demand amount and the prices is from Agriculture and Livestock Industries Corporation (2017), Ministry of Internal Affairs and Communications (1992–2016).

The imported beef data uses Ministry of Finance (2017).
(2) Model

In this study, per capita demand for beef is specified by LA/AIDS as follows:

\[ w_i = \sum_k c_{ik} \cdot Dumm_i + \tau_i \cdot trend + \sum_j \gamma_{ij} \cdot \ln p_j + \beta_i \cdot \ln \left( \frac{X}{P} \right) + e_i \] (1)

where \( w_i, p_j, \) and \( X \) are the expenditure share of item \( i, \) the price of item \( j, \) and the total expenditure, respectively. \( P^L \) denotes the Laspeyres-type price index, and \( e \) represents the error term. We add dummy variable to the constant term to account for the effect of soaring calf price since 2014. The four food items that are analyzed are Wagyu beef, hybrid beef, dairy steer beef, and imported beef (i, j=1, ..., 4). The parameters to be estimated are \( a, \tau, \beta, \) and \( \gamma. \) \( P^L \) is derived from the following formula:

\[ \ln P^L = \sum_i \tilde{w}_i \cdot \ln p_i \] (2)

where \( \tilde{w}_i \) is the average expenditure share of item \( i. \)

The following theoretical restrictions are imposed on the parameters:

\[ \sum_i a_{ik} = 1, \sum_i \beta_i = 0, \sum_i \gamma_{ij} = 0, \sum_i \tau_i = 0 \]

(Adding-up),

\[ \sum_j \gamma_{ij} = 0, \] (Homogeneity),

and

\[ \gamma_{ij} = \gamma_{ji}, \] (Symmetry).

When \( q_i \) denotes the quantity of item \( i \) purchased per capita, the expenditure and uncompensated price elasticities of item \( i, \) that is, \( E_{ix} \) and \( E_{ij} \) are given by the following:

\[ E_{ix} = \frac{\partial \ln q_i}{\partial \ln X} = 1 + \beta_i / w_i \] (6)

\[ E_{ij} = \frac{\partial \ln q_i}{\partial \ln p_j} = -\delta_{ij} + \gamma_{ij} / w_i - \beta_i \cdot w_j / w_i \] (7)

where \( \delta_{ij} \) is the Kronecker delta (if \( i=j \) then \( \delta_{ij}=1; \) otherwise, \( \delta_{ij}=0). \)

The compensated price elasticities are estimated by the Slutsky equation.

\[ E_{ij}^c = E_{ij} + E_{ix} \cdot w_j \] (8)

(3) Estimation results

The parameters of equation (1) are estimated simultaneously with the theoretical restrictions imposed in equations (3), (4), and (5) using the seemingly unrelated regressions method. Table 1 shows the results of the estimation, and the corresponding R-squared for Wagyu beef, hybrid beef, and dairy steer beef. The result shows that 20 out of 26 estimated parameters are statistically significant at the 5% significance level. The parameter \( \alpha_{ik}, \) which indicates the average expenditure share of item, is statistically significant at the 1% level. Given the

| Parameter | Estimate | t-statistic | Parameter | Estimate | t-statistic | Parameter | Estimate | t-statistic |
|-----------|----------|-------------|-----------|----------|-------------|-----------|----------|-------------|
| \( \alpha_{i1} \) | 0.390 | *** | \( \beta_1 \) | -0.026 | | \( \alpha_{4} \) | 0.002 | | \( \gamma_{4} \) | 0.023 | *** |
| \( \alpha_{i2} \) | 0.378 | *** | \( \beta_2 \) | -0.132 | | \( \gamma_{4} \) | 0.230 | *** |
| \( \alpha_{i3} \) | 0.174 | *** | \( \gamma_{1} \) | 0.152 | *** | \( \tau_{1} \) | 0.020 | *** |
| \( \alpha_{i4} \) | 0.178 | *** | \( \gamma_{2} \) | 0.068 | *** | \( \tau_{2} \) | -0.015 | *** |
| \( \alpha_{i5} \) | 0.089 | *** | \( \gamma_{3} \) | -0.072 | *** | \( \tau_{3} \) | -0.016 | *** |
| \( \alpha_{i6} \) | 0.091 | *** | \( \gamma_{4} \) | -0.148 | *** | \( \tau_{4} \) | 0.011 | | Wagyu beef: \( R^2=0.934 \)
| \( \alpha_{i7} \) | 0.347 | *** | \( \gamma_{2} \) | -0.023 | | \( \gamma_{4} \) | 0.030 | *** |
| \( \alpha_{i8} \) | 0.353 | *** | \( \gamma_{3} \) | 0.038 | *** | \( \gamma_{3} \) | 0.083 | *** |
| \( \beta_1 \) | 0.172 | *** | \( \gamma_{4} \) | -0.083 | *** | \( \gamma_{3} \) | 0.033 | *** |
| \( \beta_2 \) | -0.014 | -0.196 | \( \gamma_{3} \) | 5.851 | | hybrid beef: \( R^2=0.932 \)

1) ** and *** denote significance at 5% and 1% levels, respectively.
estimated signs of parameter $\beta_i$, hybrid beef, dairy steer beef, and imported beef are considered as necessities, while Wagyu beef is a luxury item.

Table 2. Estimates of expenditure and uncompensated price elasticities

|                         | Wagyu beef | hybrid beef | dairy steer beef | imported beef |
|-------------------------|------------|-------------|------------------|--------------|
| expenditure elasticity  | 1.430 ***  | 0.900 *     | 0.642 *          | 0.658 **     |
|                         | (9.572)    | (1.764)     | (1.672)          | (2.116)      |
| uncompensated price elasticity |         |             |                  |              |
| Wagyu beef              | -0.791 ***| 0.517 **    | -0.860 ***       | -0.248 *     |
|                         | (-7.592)   | (2.147)     | (-3.826)         | (-1.854)     |
| hybrid beef             | 0.110 **   | -1.144 ***  | 0.572 ***        | -0.167 **    |
|                         | (2.367)    | (-7.231)    | (4.949)          | (-2.408)     |
| dairy steer beef        | -0.212 *** | 0.269 ***   | -0.517 ***       | 0.029        |
|                         | (-7.360)   | (4.139)     | (-6.394)         | (0.937)      |
| imported beef           | -0.536 *** | -0.542 **   | 0.164            | -0.272 *     |
|                         | (-6.670)   | (-2.041)    | (0.817)          | (-1.661)     |

1) Figures in parentheses are t-values. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

Table 3. Estimates of compensated price elasticities

|                         | Wagyu beef | hybrid beef | dairy steer beef | imported beef |
|-------------------------|------------|-------------|------------------|--------------|
| compensated price elasticity |         |             |                  |              |
| Wagyu beef              | -0.220 ***| 0.877 ***   | -0.604 ***       | 0.015        |
|                         | (-2.758)   | (7.095)     | (-3.907)         | (0.262)      |
| hybrid beef             | 0.315 ***  | -1.015 ***  | 0.664 ***        | -0.073       |
|                         | (7.095)    | (-6.746)    | (6.144)          | (-1.244)     |
| dairy steer beef        | -0.109 *** | 0.334 ***   | -0.471 ***       | 0.077 ***    |
|                         | (-3.907)   | (6.144)     | (-6.025)         | (3.256)      |
| imported beef           | 0.014      | -0.196      | 0.410 ***        | -0.019       |
|                         | (0.262)    | (-1.244)    | (3.256)          | (-0.189)     |

1) Figures in parentheses are t-values. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

4. Conclusion

There was originally a gap between generations in terms of beef purchase unit prices, and this gap is gradually expanding (Fig. 4). Japanese eating habits have become polarized into the younger generation’s low price and convenience-oriented purchases versus those of the domestic and health-conscious senior generations.

Despite the fact that the quantity of imported beef will increase by 2.20%. Simultaneously, the amount of hybrid beef consumed will decrease by 8.77%. Domestic beef has a large “collapse” effect, especially among adjacent cattle species, while imported beef has little influence.
consumed decreased by 40% from the influence of BSE, consumption of domestic beef did not increase. This was in partly because of the supply side and partly due to the quality requirement of customers on the demand side. As a measure to improve the “collapse” of domestic beef consumption, differentiation incorporating the recent red meat consciousness is consistent with health consciousness and is considered effective.

Notes
1 The calculated method of the domestic beef data is referred to Takahashi and Maeda (2016).
2 The imported price is the average price in the US and Australia. And it was calculated as follows. We divide the imported value by the imported volume to obtain the CIF price. The CIF price is multiplied by the tariff rate, and the margin is added. The margin rate is calculated from Ministry of Internal Affairs and Communications (2015).
3 In this paper, the measurement data is the annual data of 12 years. Since the sample size is small, “spurious regression” is not a problem (Okimoto, 2010). And so, we estimate equation (1) by the original series.

References
Agriculture and Livestock Industries Corporation (2017) Domestic Statistics of Livestock Products. (https://www.alic.go.jp/joho-c/joho05_000073.html) [Accessed March 22, 2017] (in Japanese).
Kusakari, H. (2011) Current food consumption of households in Japan: Possibilities in cooperation with domestic agriculture. Journal of Rural Economics, 83(3), 146–160 (in Japanese with English abstract).
Matsuda, T. (2014) An analysis of Japanese demand for domestic and imported meats using nonstationary time series data. Japanese Society of Agricultural Technology Management, 20(4), 127–138 (in Japanese with English abstract).
Ministry of Agriculture, Forestry and Fisheries (Ed.) (1994–2016) Distribution Statistics of Livestock Products (1993–2015). Tokyo: Association of Agriculture and Forestry Statistics (in Japanese).
Ministry of Finance (2017) Trade Statistics of Japan. (http://www.customs.go.jp/toukei/info/index.htm) [Accessed March 22, 2017] (in Japanese).
Ministry of Internal Affairs and Communications (Ed.) (1952–2016) Annual Report on Family Income and Expenditure Survey (1951–2015). Tokyo: Ministry of Internal Affairs and Communications (in Japanese).
Ministry of Internal Affairs and Communications (Ed.) (1981–2017) Annual Report on Family Income and Expenditure Survey (1980–2016). Tokyo: Ministry of Internal Affairs and Communications (in Japanese).
Ministry of Internal Affairs and Communications (Ed.) (1992–2016) Annual Report on Family Income and Expenditure Survey (1991–2015). Tokyo: Ministry of Internal Affairs and Communications (in Japanese).
Ministry of Internal Affairs and Communications (Ed.) (2015) 2011 Input-Output Tables. Tokyo: Ministry of Internal Affairs and Communications (in Japanese).
Okimoto, T. (2010) Time series analysis of economic and financial data. Tokyo: Asakura Publishing Co., Ltd. (in Japanese).
Takahashi, K. and Maeda, K. (2016) Impacts of the TPP agreement on beef demand in Japan. Journal of Rural Economics, 88(3), 229–243 (in Japanese with English abstract).
Tani, A. and Kusakari, H. (2013) Econometric analysis of household attribution and eating habits conditional on the economy. Journal of Rural Problems, 49(1), 47–52 (in Japanese with English abstract).