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Impacts of the TPP Agreement on Beef Demand in Japan: An Analysis by Class

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The purpose of this paper is to econometrically clarify the demand structure for beef in Japan by disaggregating beef into four classes and considering the non-stationarity of time series data, and then to consider the impact of the Trans-Pacific Partnership（TPP）Agreement on the domestic production of beef. The main analysis results are as follows. First, demand for imported meats are more elastic to own price and meat expenditure compared with demand for domestically produced meats. Second, the TPP Agreement will not significantly affect the quantities demanded for Japanese beef and hybridize type beef but will decrease the quantity demanded for dairy beef by 8.6%. Third, the situation after the TPP Agreement came into effect will be different from the situation after the beef tariffication; thus, we cannot expect a mitigation effect of trade liberalization impacts, such as compensating for the decrease in production of dairy beef by the increase in production of Japanese beef.

Key words: beef demand, time series analysis, TPP Agreement, effect by class

1. Objective

The Trans-Pacific Partnership（TPP）negotiations reached an agreement in principle in October 2015, and, after setting a quantity safeguard for Japan's beef imports, it was determined that the tariff would be reduced over 16 years from 38.5% to 9%. Therefore, there are concerns in Japan about the impact that this reduction in the beef tariff will have on the domestic production of beef, particularly on the production of dairy beef, which is said to be close to imported beef in quality.

To analyze these impacts, it is primarily necessary to econometrically clarify the current demand structure for beef in Japan. Previous studies that have conducted an econometric analysis from this viewpoint are Mori and Lin（1990）, Hayes *et al.*（1990）, Wahl *et al.*（1991）, Kawashima and Sari（2010）, and Matsuda（2014）.

However, a problem with the studies done by Hayes *et al.*（1990）, Wahl *et al.*（1991）, Kawashima and Sari（2010）, and Matsuda（2014）is that they aggregated dairy beef with imported beef or Japanese beef（Wagyu beef）as one good and did not analyze the relationship between imported beef and dairy beef, which is currently particularly noteworthy.

Conversely, in Mori and Lin（1990）, although the period of the analysis was set prior to the tariffication of beef imports, after disaggregating beef into three classes—Japanese beef, dairy beef, and imported beef—they conducted an analysis using a demand system model and clarified that Japanese beef and dairy beef did not compete with imported beef. However, after the tariffication in 1991, on one hand, the quantity demanded for imported beef increased, but on the other hand, the quantity demanded for dairy beef decreased, so it appeared that imported beef and dairy beef were in a competitive relationship.

Furthermore, a problem with the study of Mori and Lin（1990）is that they did not consider the non-stationarity of time series data. When using time series data, to prevent "spurious regression," it is necessary to use an analysis model and estimation method that takes into consideration the non-stationarity of the data;

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however, Mori and Lin (1990) did not consider this and conducted a regression analysis.

A study that considered the non-stationarity of time series data and that carried out the analysis using a demand system model is Matsuda (2014). After conducting a unit root test and co-integration test, Matsuda (2014) used first difference series data and analyzed the demand structure for meat in Japan. However, as previously touched upon, a problem with Matsuda (2014) is that it aggregated domestically produced beef as one good and did not analyze the relationship between imported beef and dairy beef, which is currently particularly noteworthy.

Therefore, to consider the impact of the TPP Agreement on the domestic production of beef, it is important to carry out an analysis that overcomes the problems in both Mori and Lin (1990) and Matsuda (2014); namely, disaggregating the beef into classes and considering the non-stationarity of time series data. In addition, a problem in all the above studies is that they did not explicitly analyze the demand for hybridize type beef (first filial generation beef), which currently occupies an important position in the domestic production of beef.

Therefore, after disaggregating beef into four classes—Japanese beef, hybridize type beef, dairy beef, and imported beef—and considering the non-stationarity of time series data, the objective of this study is to econometrically clarify the current demand structure for beef in Japan, and to consider the impact of the TPP Agreement on the domestic production of beef.

The remainder of this paper is structured as follows. First, in Section 2, the methods of selecting the analysis model and the estimation method will be explained, and in Section 3, the data will be described. Then, in Section 4, the unit root test and co-integration test will be carried out, and the method that is suitable for this study to estimate the time series data will be selected. In Section 5, the demand structures for meat and beef in Japan will be estimated, and the estimation results will be considered in Section 6. Furthermore, in Section 7, the impacts of the TPP Agreement will be analyzed using the results obtained, and then the impact of the TPP Agreement on the domestic production of beef will be considered. Finally, in Section 8, this study will be summarized, and the remaining issues for future research will be described.

2. The Methods of Selecting the Analysis Model and Estimation Method

In this study, the demand structure for beef in Japan is estimated using the linear approximate almost ideal demand system (LA/AIDS) model, which is a linear approximation of the almost ideal demand system model (Deaton and Muellbauer, 1980). The LA/AIDS model is expressed as follows.

$$w_{it}=\alpha_i+\sum_{j=1}^{n}\gamma_{ij}\ln p_{jt}+\beta_i[\ln X_t-\ln P_t]+u_{it} \quad (1)$$

Here, w_{it} is the expenditure share of item i in period t, p_{jt} is the price of item j in period t, X_t is the total expenditure on the target items in period t, P_t is the price index in period t, u_{it} is the error term of item i in period t, and α_i, γ_{ij}, and β_i are the parameters.

For the price index in the above-described model, the following log-linear analogue of the Laspeyres price index is used.

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

Here, $\overline{w}_i$ is the sample mean value of the expenditure share of item i.

Also, in the above-described model, the adding-up restriction ($\sum_{i=1}^{n}\alpha_i=1$, $\sum_{i=1}^{n}\gamma_{ij}=\sum_{i=1}^{n}\beta_i=0$), the homogeneity restriction ($\sum_{j=1}^{n}\gamma_{ij}=0$), and the symmetry restriction ($\gamma_{ij}=\gamma_{ji}$) are imposed.

If the original series of the time series data is a stationary process, there will be no problems, even if a regression analysis is performed using Equation (1). However, if the original series of the time series data is a non-stationary process, performing a regression analysis using Equation (1) will result in "spurious regression," so it is necessary to take measures against this concern, such as differencing the data until they become stationary processes.

The time series data that becomes a stationary process after differencing d times is expressed as I (d) (integrated of order d). Matsuda (2014) stated that nearly all non-stationary economic time series are I (1); therefore, the following three methods will be primarily considered for estimating the analysis model. First, if all the variables in an analysis model are I (0), the regression estimation is performed using the original series. Second, if all the variables in an analysis model are I (1) and there is a co-integration relationship among the variables, the regression estimation is performed using the error correction model. Third, if all the variables in an analysis model are I (1) and there is no co-integration relationship among the variables, the regression estimation is performed using the first difference series.

In this study, a unit root test and co-integration test are carried out and the estimation method that is suitable for this study is selected from the three methods described above.

3. The Data

In this study, the subjects of the analysis are eight types of meat; specifically, four classes of beef—Japanese beef, hybridize type beef, dairy beef, and imported beef—as well as domestically produced pork, imported pork, domestically produced chicken, and imported chicken. The period of the analysis is set as January 2006 to February 2011.[1] The quantity demanded and the price of each type of meat are calculated as shown below, with reference to the supply and demand table published by the Agriculture & Livestock Industries Corporation (2015) for each of the meats.[2]

First, the estimated marketing quantity for all the meats is used for the quantity demanded. The estimated marketing quantity of domestically produced meats is calculated by subtracting the export quantity and the quantity of stock increase from the production quantity.[3] However, only the quantity of stock increase is subtracted for domestically produced chicken. Also, the estimated marketing quantity of imported meats is calculated by subtracting the quantity of stock increase from the import quantity.

For the production quantities of Japanese beef, hybridize type beef, dairy beef, and domestically produced pork, the production quantity of dressed carcass is used, and for domestically produced chicken, the production quantity published by the Agriculture & Livestock Industries Corporation (2015) is used.[4] Also, data on the stock quantity and export quantity for domestically produced beef by class—Japanese beef, hybridize type beef, and dairy beef—cannot be obtained. Therefore, the estimated marketing quantity of each class of beef is calculated by multiplying the respective ratios of the production quantity of each class to the total production quantity of domestically produced beef (= the dressed carcass production quantity of each class / the total dressed carcass production quantity of domestically produced beef) by the total estimated marketing quantity of domestically produced beef. Further, the estimated marketing quantities of beef and pork are converted to a cut meat basis; that of domestically produced chicken is converted to a boneless dressed carcass basis, and that of imported chicken is an actual quantity basis.

Next, concerning price, for Japanese beef, hybridize type beef, and dairy beef, the wholesale dressed carcass prices on the meat central wholesale markets converted to a cut meat basis are used, and for imported beef, the average market (trader's) price of beef produced in Australia and the United States is used. For domestically produced pork, the wholesale dressed carcass price on the meat central wholesale markets converted to a cut meat basis is used, and for imported pork, the average market (trader's) price of pork produced in the United States, Canada, Denmark, and Mexico is used. For domestically produced chicken, the wholesale boneless dressed carcass price in Tokyo is used, and for imported chicken, the average market price in the Kanto district of chicken produced in Brazil and the United States is used. All prices are converted to real prices using "All items" in the "Consumer Price Index (2010 standards)" of the Ministry of Internal Affairs and Communications, and converted to prices including consumption tax.

The prices of imported beef, imported pork, and imported chicken are all calculated as weighted averages of the prices of each respective country's produce, which is calculated as the simple average of the prices by cut of each country, with the import quantity of the produce of each country in the relevant month as the weights.[5] In addition, the price of domestically produced chicken is calculated by weighting the prices of "leg meat" and "breast meat," with the weight ratios of each respective cut obtained from one chicken as the weights.

Further, for the production quantities and prices of

1) The period of analysis is set in consideration of the fact that monthly data on the dressed carcass production quantity for hybridize type beef can be obtained from January 2006, that the Great East Japan Earthquake occurred in March 2011, and moreover, that the price of imported chicken has not been published since April 2011.

2) In this study, as in Mori and Lin (1990) and in Matsuda (2014), meat wholesale data is used. As noted by Mori and Lin (1990), the application of wholesale data to a demand system model based on a theory of households lacks a rationale, strictly speaking. However, in the context of the increasing importance in meat demand of meat for processing and commercial use, for the analysis of the impact of the TPP Agreement on domestic demand as a whole, including for these usages, it is not appropriate to use data on household economies, such as from the "Family Income and Expenditure Survey" and point of sale system. Therefore, this study uses wholesale data that reflect domestic demand as a whole, including for processing and commercial use.

3) The export quantities of beef and pork do not include edible offal and boiled meat.

4) The data on the production quantity of domestically produced chicken published by the Agriculture & Livestock Industries Corporation (2015) is an estimation by the Ministry of Agriculture, Forestry and Fisheries up to February 2010 and by the Agriculture & Livestock Industries Corporation from March 2010.

Table 1. The sample means and sample standard deviations of the quantity demanded, price, and expenditure share (from January 2006 to February 2011) (Unit: tons, yen/kg)

	Japanese beef (i= 1)	Hybridize type beef (i= 2)	Dairy beef (i= 3)	Imported beef (i= 4)	Domestically produced pork (i= 5)	Imported pork (i= 6)	Domestically produced chicken (i= 7)	Imported chicken (i= 8)
Quantity demanded	11,909.4 (2,065.3)	7,467.3 (793.3)	9,681.2 (814.4)	39,159.4 (5,006.2)	73,966.1 (5,322.7)	63,128.1 (6,196.7)	81,463.9 (5,692.7)	32,029.9 (4,153.4)
Price	2,623.0 (253.6)	1,648.7 (170.5)	804.9 (98.5)	972.4 (86.9)	611.1 (75.9)	634.2 (24.4)	469.7 (54.6)	452.3 (45.6)
Expenditure share	0.137 (0.017)	0.054 (0.005)	0.035 (0.006)	0.167 (0.016)	0.198 (0.013)	0.177 (0.015)	0.169 (0.018)	0.064 (0.008)

Note: The upper row shows the sample mean and the lower row in parentheses shows the sample standard deviation.

Japanese beef, hybridize type beef, and dairy beef, the data on "cow," "castrated," and "bull" are used. However, some data on Japanese beef, such as the wholesale dressed carcass value of "bull," is not published. Therefore, for the price of Japanese beef, only the data on "cow" and "castrated" are used.

The following respective data sets are used for the above-described quantities and prices. First, data from the Agriculture & Livestock Industries Corporation (2015) is used for the market (trader's) or wholesale prices of imported beef, imported pork, domestically produced chicken, and imported chicken, and the stock quantities of each of the meats.[6)] Second, "Livestock Distribution Statistics" from the Ministry of Agriculture, Forestry and Fisheries is used for the dressed carcass production quantities and the wholesale dressed carcass prices in the meat central wholesale markets of beef and pork. Third, the "Trade Statistics of Japan" from the Ministry of Finance is used for the import and export quantities of each of the meats. Fourth, the Agriculture & Livestock Industries Corporation (2010) is used for the methods of aggregating each of the import quantities and export quantities, and the yields from a dressed carcass to cut meat of beef and pork; the Agriculture & Livestock Industries Corporation (2001) is used for the method of aggregating the import quantity of chicken; and the "Food Balance Sheet" from the Ministry of Agriculture, Forestry and Fisheries is used for the yield of domestically produced chicken from meat with bone to boneless dressed carcass; and the Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries (2013) is used for the weight ratios of "leg meat" and "breast meat" obtained from one chicken.

Table 1 shows the sample means and the sample standard deviations of quantity demanded, price, and expenditure share from the above calculations.

5) The specific procedure for processing the prices of imported meats is as follows.

First, with regards to imported beef, for the produce of Australia, the simple average price of a total of 31 cuts is calculated, including 11 frozen cuts (chuck roll, clod, point-end brisket, navel-end brisket, thick flank, topside, trimming (80CL), silverside, cow meat (85CL), thick skirt, and thin skirt), 8 chilled grain short-fed cuts (full set, chuck roll, point-end brisket, navel-end brisket, cube roll, striploin, tenderloin, and topside), and 12 chilled grass-fed cuts (full set, chuck roll, clod, point-end brisket, navel-end brisket, chuck tender, cube roll, striploin, tenderloin, d-rump, thick flank, and topside). Next, for the produce of the United States, the simple average price of 6 chilled cuts (boneless short ribs, hanging tender, outside skirt, tongue, chuckeye roll, and chuck rib (chuck short ribs)) is calculated. However, the prices of U.S. produced beef by cut were not published from January 2006 to March 2007 because of the decrease in the domestic distribution quantity of U.S. produced beef due to the impact of an outbreak of bovine spongiform encephalopathy (BSE) in the United States. Therefore, from January 2006 to March 2007, the simple average price of 31 Australian produced cuts is used, and from April 2007 to February 2011, the weighted average price of Australian and U.S. produced cuts calculated with the import quantities of these two countries in the relevant month as the weights is used.

Second, with regards to imported pork, first the simple average prices are calculated of 7 U.S. produced cuts (chilled loin, chilled tenderloin, chilled butt, chilled picnic, chilled belly, frozen tenderloin, and frozen picnic), 9 Canadian produced cuts (chilled backs, chilled tenderloin, chilled butt, frozen backs, frozen tenderloin, frozen butt, frozen picnic, frozen belly, and frozen ham), 4 Danish produced cuts (frozen table loin, frozen tenderloin, frozen collar, and frozen belly), and 2 Mexican produced cuts (chilled loin and chilled belly). With the import quantities of U.S., Canadian, Danish, and Mexican produce in the relevant month as the weights, the weighted average price of the produce from the four above-mentioned countries is calculated.

Third, for imported chicken, the weighted average price of Brazil-produced leg meat and U.S. produced leg meat with bones is calculated, with the import quantities from these two countries in the relevant month as the weights.

4. The Results of the Unit Root Test and Co-Integration Test

To select a method of estimating the time series data that is suitable for this study, first, a unit root test is carried out. In this study, for the total of 45 variables, the variables used in the LA/AIDS model, and the natural logarithms of the relative price variables, an augmented Dickey-Fuller test (Dickey and Fuller, 1979; ADF test) and a Phillips-Perron test (Phillips and Perron, 1988; PP test) are carried out on each of 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).[7] The results of the unit root test are shown in Table 2.[8]

Table 2. Results of the unit root test

Variables	Original series		Difference series		Seasonal difference series	
	ADF test statistics	PP test statistics	ADF test statistics	PP test statistics	ADF test statistics	PP test statistics
w_1	−1.547	−27.720**	−1.855	−80.838***	−1.811	−15.822**
w_2	−1.564	−19.610*	−1.739	−79.966***	−2.309	−11.383*
w_3	−1.892	−21.467*	−2.976**	−64.181***	−1.715	−20.959***
w_4	−1.051	−72.093***	−1.723	−82.917***	−2.226	−71.224***
w_5	−4.206***	−30.163***	−4.553***	−54.546***	−4.156***	−31.995***
w_6	−3.667**	−55.981***	−5.431***	−67.910***	−3.490***	−38.870***
w_7	−0.839	−11.993	−1.350	−76.650***	−1.705	−17.696**
w_8	−3.119	−38.241***	−3.670***	−56.023***	−1.710	−39.063***
$\ln p_1$	−2.257	−6.976	−3.522***	−59.492***	−0.945	−5.703
$\ln p_2$	−0.151	0.253	−1.820	−68.495***	0.249	−0.250
$\ln p_3$	−2.500	−5.242	−4.712***	−52.880***	−2.560	−5.581
$\ln p_4$	−1.928	−5.667	−1.674	−35.603***	−1.941	−4.913
$\ln p_5$	−2.007	−4.423	−4.094***	−36.240***	−1.777	−4.835
$\ln p_6$	−2.273	−6.330	−3.032**	−44.122***	−1.905	−6.100
$\ln p_7$	−2.289	−5.073	−2.467	−18.777**	−2.234	−4.795
$\ln p_8$	−2.533	−8.082	−3.563***	−30.126***	−2.167	−7.002
$\ln(p_1/p_2)$	−1.453	−3.182	−3.701***	−50.625***	−1.076	−2.571
$\ln(p_1/p_3)$	−2.349	−6.126	−4.219***	−48.307***	−2.297	−6.098
$\ln(p_1/p_4)$	−1.957	−8.537	−2.965**	−55.049***	−1.579	−7.739
$\ln(p_1/p_5)$	−1.610	−8.591	−3.614***	−33.659***	−1.771	−7.591
$\ln(p_1/p_6)$	−1.304	−12.910	−5.427***	−60.394***	−1.613	−12.121*
$\ln(p_1/p_7)$	−2.461	−5.168	−2.547	−46.550***	−2.469	−5.302
$\ln(p_1/p_8)$	−2.597	−9.020	−3.610***	−40.533***	−2.373	−8.398
$\ln(p_2/p_3)$	−3.101	−2.235	−4.175***	−47.828***	−2.383	−3.368
$\ln(p_2/p_4)$	−1.728	−5.089	−1.888	−57.598***	−1.549	−5.084
$\ln(p_2/p_5)$	−2.049	−5.343	−3.700***	−44.086***	−1.847	−7.183
$\ln(p_2/p_6)$	−0.677	−0.610	−2.107	−74.637***	−0.597	−1.750
$\ln(p_2/p_7)$	−2.136	−2.989	−2.884**	−56.191***	−2.153	−3.968

6) Agriculture & Livestock Industries Corporation (2015) published the wholesale price of domestically produced chicken obtained from the Ministry of Agriculture, Forestry and Fisheries' "*Shokuchou Shikyou Jouhou* (Survey of Broiler Wholesale Price)," and the market price of imported chicken obtained from a survey by the Japan Chicken Association.

7) Matsuda (2010) and Matsuda (2014) are referred to when performing the analysis in this study. We also followed Matsuda (2014) when deciding the lag length in the unit root test and the co-integration test, as follows. In the ADF test, if j means the lag length that minimizes AIC (Akaike's information criterion), the lag length is set as Min (j + 2, 12). Also, in the PP test, if T means a sample size, the lag length is set as 4; that is, the integer value closest to $T^{(1/3)}$.

8) DeJong *et al*. (1992) conducted a Monte Carlo experiment for the unit root test, and Haug (1996) conducted the same experiment for the co-integration test. They clarified that when the sample size is 100 or less, the results of both tests will not be sufficiently reliable. However, in this study, the sample size cannot be increased from 62 due to the data constraints. Therefore, it should be kept in mind that the results in this section are the results with a reservation on this point.

Table 2. Results of the unit root test (continued)

Variables	Original series		Difference series		Seasonal difference series	
	ADF test statistics	PP test statistics	ADF test statistics	PP test statistics	ADF test statistics	PP test statistics
$\ln(p_2/p_8)$	−1.435	−3.307	−3.697***	−46.911***	−1.588	−4.956
$\ln(p_3/p_4)$	−2.391	−8.587	−3.769***	−40.815***	−1.664	−7.455
$\ln(p_3/p_5)$	−2.158	−7.383	−5.535***	−37.455***	−1.985	−7.574
$\ln(p_3/p_6)$	−2.676	−6.641	−0.842	−56.327***	−2.213	−7.618
$\ln(p_3/p_7)$	−1.292	−8.721	−2.803*	−42.870***	−1.077	−8.056
$\ln(p_3/p_8)$	−1.996	−12.919	−2.306	−39.259***	−1.827	−11.637*
$\ln(p_4/p_5)$	−3.339*	−18.276*	−1.971	−37.538***	−2.357	−17.918**
$\ln(p_4/p_6)$	−2.111	−6.658	−2.027	−41.562***	−2.025	−6.032
$\ln(p_4/p_7)$	−1.418	−4.366	−3.230**	−56.622***	−1.699	−5.843
$\ln(p_4/p_8)$	−1.761	−9.350	−1.712	−36.604***	−2.108	−8.808
$\ln(p_5/p_6)$	−1.616	−5.644	−4.199***	−39.092***	−1.535	−5.848
$\ln(p_5/p_7)$	−1.854	−10.037	−4.777***	−34.832***	−2.170	−12.743*
$\ln(p_5/p_8)$	−2.728	−12.092	−3.194**	−37.449***	−0.814	−14.114**
$\ln(p_6/p_7)$	−2.438	−5.241	−2.482	−23.527***	−2.528	−5.115
$\ln(p_6/p_8)$	−2.430	−8.931	−4.069***	−30.106***	−2.093	−7.929
$\ln(p_7/p_8)$	−3.251*	−16.223	−2.208	−30.628***	−3.224**	−15.807**
$\ln(X/P)$	−2.360	−53.236***	−3.686***	−70.714***	−2.109	−53.364***
Critical value at 1% level	−3.96	−29.4	−3.43	−20.6	−3.43	−20.6
Critical value at 5% level	−3.41	−21.7	−2.86	−14.1	−2.86	−14.1
Critical value at 10% level	−3.13	−18.2	−2.57	−11.2	−2.57	−11.2

Notes: 1) The tests are conducted on the original series including the trend variable, the constant term and the monthly dummy variables; on the difference series including the constant term and the monthly dummy variables; and on the seasonal difference series including the constant term. The critical values are referred to Davidson and MacKinnon (1993).

2) *, **, and *** indicate that the null hypothesis of "there is a unit root" is rejected at the 10% level, 5% level, and 1% level, respectively.

As shown in Table 2, for the original series, the null hypothesis of "there is a unit root" cannot be rejected in either test for most of the variables. For the seasonal difference series, the same null hypothesis cannot be rejected in either test for most of the variables.

Conversely, for the difference series, based on the ADF test, the null hypothesis of "there is a unit root" cannot be rejected even at the 10% level for 17 variables, but based on the PP test, the same null hypothesis can be rejected for all the variables at the 5% level. In other words, for the data used in this study, the tests indicate that most of the original series are unit root processes, and it is understood that all become stationary processes by taking the first difference from one period before.

Next, to perform the co-integration test, the test methodology of Engle and Granger (1987) is used. In this study, after including the monthly dummy variables in Equation (1), a total of 4 co-integration tests are carried out: "single-equation estimations without the restrictions (homogeneity restriction and symmetry restriction) imposed" or "simultaneous estimation with the restrictions imposed," and "including trend variable" or "not including trend variable".[9] Table 3 shows the results of the co-integration test.

As shown in Table 3, in the case of single-equation estimations without the restrictions imposed, there is a possibility of rejection of the null hypothesis of "no co-

9) When conducting simultaneous estimation with the restrictions imposed, except for the imported chicken expenditure share equation, the simultaneous estimation is carried out using the iterative seemingly unrelated regression method (Kmenta and Gilbert, 1968) for the expenditure share equations of the other meats. In this case, the adding-up restriction is automatically established. Also, the time series of the error term in the imported chicken expenditure share equation is estimated *ex post facto* using the restrictions and data, etc.

Table 3. Results of the co-integration test

Expenditure share equation	Co-integration test statistics			
	Single-equation estimations without the restrictions imposed		Simultaneous estimation with the restrictions imposed	
	Including the trend variable	Not including the trend variable	Including the trend variable	Not including the trend variable
Japanese beef	−4.539	−4.478	−2.192	−1.937
Hybridize type beef	−2.028	−2.064	−1.673	−1.198
Dairy beef	−3.311	−2.835	−2.954	−2.554
Imported beef	−2.831	−2.269	−2.242	−2.335
Domestically produced pork	−4.074	−4.154	−3.848	−3.574
Imported pork	−3.701	−4.603	−4.709	−2.951
Domestically produced chicken	−3.698	−3.619	−3.255	−3.305
Imported chicken	−5.381	−3.695	−2.968	−3.258
Critical value at 1% level	−5.52	−5.25	−5.52	−5.25
Critical value at 5% level	−4.98	−4.71	−4.98	−4.71
Critical value at 10% level	−4.70	−4.42	−4.70	−4.42

Notes: 1) All of the critical values within the table are the values when the number of explanatory variables (the constant term is counted, the trend variable is not counted) is 6 (Davidson and MacKinnon, 1993). In the case of this study, the number of explanatory variables (including the constant term, not including the monthly dummy variables and the trend variable) is 9 when the restrictions are imposed and 10 when the restrictions are not imposed.

2) The restrictions indicate the homogeneity restriction and the symmetry restriction.

integration" in the imported chicken expenditure share equation when the trend variable is included, and in the Japanese beef and imported pork expenditure share equations when the trend variable is not included. Conversely, in the case of the simultaneous estimation with the restrictions imposed, regardless of whether there is a trend variable, the null hypothesis of "no co-integration" is not rejected even at the 10% level in the expenditure share equations of all the meats.[10)]

As explained below, in this study, the simultaneous estimation is carried out with restrictions imposed and without a trend variable, so it is not considered to be a problem even if the analysis is performed under the assumption that there is no co-integration relationship for the expenditure share equations of all the meats. Therefore, in this study, the regression estimation is carried out using a first difference series.

5. Estimation Results of the Demand Structure

Based on the results of the unit root test and the co-integration test, the following analysis model is used in this study to estimate the demand structures for meat and beef in Japan.

$$\Delta w_{it} = \sum_{j=1}^{n} \gamma_{ij} \Delta \ln p_{jt} + \beta_i [\Delta \ln X_t - \Delta \ln P_t] + \sum_{s=2}^{12} d_{is} \Delta DM_s + \Delta u_{it} \quad (3)$$

Here, Δ expresses the first difference from one period before, DM_s is the monthly dummy variable that takes 1 for month s and zero for all months other than month s, and d_{is} is the parameter.

In addition, as serial correlation in the error term

10) The absolute value of the critical value of the co-integration test increases as the number of explanatory variables increases, but in Davidson and MacKinnon (1993), the critical values are only shown up to 6 explanatory variables (the constant term is counted, the trend variable is not counted). For this study, the number of explanatory variables (including the constant term, not including the monthly dummy variables and the trend variable) is 9 when the restrictions are imposed and 10 when the restrictions are not imposed. Therefore, even for the imported pork expenditure share equation (test statistic = −4.709), in the case of simultaneous estimation with the restrictions imposed and including the trend variable, it is considered that there is no co-integration relationship at the 10% level.

Table 4. Results of the likelihood-ratio test on the homogeneity restriction and symmetry restriction

Type of restriction	Log-likelihood	Likelihood-ratio test statistics	Critical values at 5% level of χ^2 distribution	Degrees of freedom
No restriction	1786.583	—	—	—
Homogeneity restriction	1783.258	6.650	14.067	7
Homogeneity and symmetry restrictions	1766.682	39.802	41.337	28

was implied by the previous estimation, the estimation is carried out assuming that there is a first-order serial correlation in the error term. Also, in the expenditure share equations of all the meats, the constant terms were not significant even at the 10% level, so the constant terms are not included when carrying out the estimation. Based on the above points, each of the meats' expenditure share equations are simultaneously estimated using the nonlinear iterative seemingly unrelated regression method (Gallant, 1987).[11)]

Table 4 shows the results of the likelihood-ratio test for the homogeneity restriction and the symmetry restriction. As shown in Table 4, neither of the null hypotheses, that the "homogeneity restriction is established," and that the "homogeneity restriction and symmetry restriction are simultaneously established," are rejected at the 5% level. Therefore, it is considered that there are no problems in conducting the estimation with the homogeneity restriction and the symmetry restriction imposed.

Table 5 shows the estimation results of the expenditure share equations of each of the meats. The coefficients of determination are from 0.602 to 0.921, and it is considered that generally good estimation results can be obtained.

Furthermore, Table 6 shows the estimated values of the price elasticities of demand and the meat expenditure elasticities of demand for each meat. The delta method is used to obtain the standard error of each elasticity.

6. Demand Structures for Meat and Beef in Japan

Based on the elasticities shown in Table 6, demand structures for meat and beef in Japan are considered in this section. Empirically, it is expected that the uncompensated cross-price elasticity of demand shows a positive value, but as seen in Table 6, the cross-price elasticities among many of the meats, including domestically produced pork and imported pork, are estimated to be significantly negative values, and it is considered that there is a problem in accepting these significant gross complementary relationships.[12)] Therefore, interpreting these estimation results is set as a future issue, and in this section, we shall consider those parts other than the significant gross complementary relationships.

First, focusing on the own price elasticity of each meat, although the absolute values of all the estimated values are less than 1, it is estimated that all the values of the imported meats are more elastic than the values of the domestically produced meats. In addition, domestically produced meats are estimated to be significant or not significant, but all imported meats are estimated to be significant. Therefore, it can be said that reducing the price of each of the imported meats will significantly increase the quantity demanded for each respective imported meat.

Second, focusing on the meat expenditure elasticity of each meat, on the one hand, all domestically produced meats are estimated to be significant or not significant with a value of less than 1, but on the other hand, all imported meats are estimated to be significant with a value of 1 or more. Considering these estimation results together with the estimation results of the own price elasticity, we understand that the responses to own price and meat expenditure are larger for the demand for imported meats than for domestically produced meats. The above results imply that im-

11) In the estimation of Equation (3), with ρ, e_{it} as the parameter and the stochastic variable, assuming that there is the relationship of $\Delta u_{it} = \rho \Delta u_{it-1} + e_{it}$ in the error term, Yen and Chern's (1992) method is used. With regard to the imported chicken parameters, after carrying out the simultaneous estimation of the expenditure share equations for all the meats except for imported chicken, it is estimated *ex post facto* using the restrictions, etc. Also, the delta method is used to calculate its standard error. Greene (2012) and others were referred to for the delta method.

12) In Mori and Lin (1990) and Matsuda (2014), the significant gross complementary relationships were estimated among many of the meats.

Table 5. Estimation results of the expenditure share equations for each meat

parameter	Japanese beef	Hybridize type beef	Dairy beef	Imported beef	Domestically produced pork	Imported pork	Domestically produced chicken	Imported chicken
ρ	−0.456***							
	(−10.268)							
β_i	−0.081***	−0.039***	−0.021***	0.194***	−0.056**	0.076*	−0.144***	0.071**
	(−3.136)	(−3.674)	(−3.596)	(2.949)	(−2.327)	(1.904)	(−8.867)	(2.255)
γ_{i1}	0.044							
	(1.649)							
γ_{i2}	−0.011	0.040***						
	(−0.967)	(5.361)						
γ_{i3}	−0.013**	0.000	0.032***					
	(−2.207)	(0.023)	(7.580)					
γ_{i4}	0.022	−0.004	0.013**	0.059				
	(0.882)	(−0.340)	(2.129)	(0.906)				
γ_{i5}	−0.015	−0.012**	−0.008***	0.019	0.142***			
	(−1.222)	(−2.374)	(−2.609)	(0.878)	(11.330)			
γ_{i6}	0.037	−0.001	−0.009	−0.038	−0.066***	0.049		
	(0.999)	(−0.063)	(−0.935)	(−0.968)	(−3.338)	(0.694)		
γ_{i7}	−0.036**	−0.000	−0.009*	−0.059***	−0.047***	−0.000	0.134***	
	(−2.545)	(−0.000)	(−1.883)	(−3.271)	(−5.646)	(−0.000)	(8.336)	
γ_{i8}	−0.029*	−0.012**	−0.006*	−0.012	−0.013	0.027	0.017*	0.028
	(−1.954)	(−2.045)	(−1.940)	(−0.447)	(−1.143)	(1.190)	(1.764)	(1.346)
d_{i2}	0.010***	0.003*	0.000	−0.011	−0.013***	0.012**	−0.004*	0.004
	(2.899)	(1.938)	(0.141)	(−1.360)	(−4.330)	(2.351)	(−1.881)	(0.930)
d_{i3}	0.012***	0.004***	0.002*	−0.012	−0.012***	0.006	0.003	−0.003
	(2.911)	(2.593)	(1.781)	(−1.229)	(−3.188)	(0.941)	(1.144)	(−0.614)
d_{i4}	0.030***	0.010***	0.001	−0.017	−0.028***	0.004	0.001	−0.002
	(5.886)	(4.855)	(0.726)	(−1.423)	(−5.991)	(0.530)	(0.260)	(−0.251)
d_{i5}	0.009**	0.004**	−0.000	−0.024**	−0.018***	0.019***	0.006*	0.004
	(2.099)	(2.206)	(−0.230)	(−2.392)	(−4.375)	(2.680)	(1.966)	(0.715)
d_{i6}	0.004	0.001	−0.001	−0.012	−0.025***	0.027***	0.002	0.002
	(0.748)	(0.588)	(−0.357)	(−0.927)	(−4.638)	(3.023)	(0.577)	(0.316)
d_{i7}	0.026***	0.006**	−0.001	−0.026**	−0.028***	0.026***	−0.003	−0.000
	(4.599)	(2.301)	(−0.450)	(−2.145)	(−5.431)	(2.909)	(−0.658)	(−0.072)
d_{i8}	0.007	0.003	−0.001	−0.015	−0.029***	0.037***	−0.007*	0.005
	(1.289)	(1.546)	(−0.458)	(−1.394)	(−6.447)	(4.608)	(−1.964)	(0.955)
d_{i9}	0.013***	0.005**	0.001	−0.017	−0.017***	0.016**	−0.003	0.003
	(2.632)	(2.253)	(0.693)	(−1.572)	(−4.026)	(2.082)	(−0.782)	(0.556)
d_{i10}	0.019***	0.006***	0.002	−0.028**	−0.013***	0.010	0.011***	−0.006
	(3.620)	(2.650)	(1.344)	(−2.214)	(−2.771)	(1.174)	(2.876)	(−0.897)
d_{i11}	0.049***	0.009***	0.002	−0.045***	−0.012**	−0.001	0.009**	−0.010
	(9.402)	(4.233)	(1.261)	(−3.552)	(−2.578)	(−0.107)	(2.507)	(−1.531)
d_{i12}	0.066***	0.010***	0.000	−0.051***	−0.018***	−0.022**	0.028***	−0.014*
	(9.662)	(3.736)	(0.122)	(−3.066)	(−2.849)	(−2.034)	(6.535)	(−1.733)
R^2	0.921	0.730	0.822	0.602	0.864	0.633	0.920	
DW	2.774	2.568	2.432	2.717	2.371	2.515	1.706	

Notes: 1) The upper row shows the estimated value and the lower row in parentheses shows the t value.

2) The critical value of the t distribution in the degrees of freedom for demand system of 307 is 1.650 at the 10% level, 1.968 at the 5% level, and 2.592 at the 1% level. Also, *, **, and *** indicate that the estimated value is statistically significant at the 10% level, 5% level, and 1% level, respectively.

3) ρ stands for the first-order autocorrelation coefficient in error term, R^2 stands for the coefficient of determination, and DW stands for Durbin Watson statistic.

Table 6. The estimated values of the price elasticity and meat expenditure elasticity of demand

price \ quantity demanded	Japanese beef	Hybridize type beef	Dairy beef	Imported beef	Domestically produced pork	Imported pork	Domestically produced chicken	Imported chicken
Japanese beef	−0.599 *** (−3.028)	−0.101 (−0.482)	−0.292 * (−1.700)	−0.025 (−0.157)	−0.037 (−0.570)	0.151 (0.705)	−0.095 (−1.113)	−0.602 ** (−2.480)
Hybridize type beef	−0.047 (−0.564)	−0.224 (−1.613)	0.035 (0.320)	−0.085 (−1.253)	−0.046 * (−1.708)	−0.029 (−0.301)	0.046 (1.120)	−0.253 ** (−2.555)
Dairy beef	−0.074 * (−1.707)	0.026 (0.387)	−0.068 (−0.569)	0.036 (0.946)	−0.028 * (−1.864)	−0.063 (−1.206)	−0.024 (−0.837)	−0.138 ** (−2.546)
Imported beef	0.262 (1.384)	0.053 (0.265)	0.469 *** (2.651)	−0.842 ** (−2.110)	0.141 (1.284)	−0.285 (−1.260)	−0.208 * (−1.902)	−0.376 (−0.853)
Domestically produced pork	0.008 (0.080)	−0.082 (−0.796)	−0.101 (−1.114)	−0.119 (−0.806)	−0.230 *** (−3.416)	−0.456 *** (−3.780)	−0.108 ** (−2.035)	−0.424 ** (−2.098)
Imported pork	0.376 (1.385)	0.108 (0.349)	−0.143 (−0.539)	−0.431 * (−1.780)	−0.281 *** (−2.776)	−0.800 ** (−2.021)	0.151 (1.052)	0.231 (0.621)
Domestically produced chicken	−0.162 (−1.494)	0.121 (0.919)	−0.161 (−1.125)	−0.550 *** (−4.362)	−0.189 *** (−4.020)	−0.072 (−0.502)	−0.061 (−0.627)	0.076 (0.442)
Imported chicken	−0.172 (−1.625)	−0.182 * (−1.656)	−0.145 (−1.561)	−0.146 (−0.914)	−0.047 (−0.836)	0.128 (0.994)	0.155 *** (2.768)	−0.631 * (−1.962)
Meat expenditure	0.408 ** (2.163)	0.280 (1.429)	0.406 ** (2.463)	2.162 *** (5.486)	0.717 *** (5.887)	1.427 *** (6.358)	0.144 (1.487)	2.117 *** (4.274)

Notes: 1) The upper row shows the estimated value and the lower row in parentheses shows the t value.

2) The critical value of the t distribution in the degrees of freedom for demand system of 307 is 1.650 at the 10% level, 1.968 at the 5% level, and 2.592 at the 1% level. Also, *, **, and *** indicate that the estimated value is statistically significant at the 10% level, 5% level, and 1% level, respectively.

3) The values are evaluated by mean of the expenditure share during the period of the analysis.

ported meats and domestically produced meats have different consumption tendencies, and compared to domestically produced meats, there is more room for increasing demand for imported meats that are more elastic with respect to own price and meat expenditure.

Third, focusing on the cross-price elasticities between domestically produced chicken and imported chicken, the elasticity of demand for domestically produced chicken to the price of imported chicken is estimated to be 0.155 and significant, so it can be said that reducing the price of imported chicken will significantly decrease the demand for domestically produced chicken.

Fourth, focusing on the cross-price elasticities among the beef classes, neither of the elasticities of demand for Japanese beef or hybridize type beef to the price of imported beef are estimated to be significant, so it cannot be said that reducing the price of imported beef will significantly decrease the demand for Japanese beef and hybridize type beef. Conversely, the elasticity of demand for dairy beef to the price of imported beef is estimated to be 0.469 and significant, so it can be said that reducing the price of imported beef will significantly decrease the demand for dairy beef.

The estimation results of the demand structure for beef described above support the considerations of the Ministry of Agriculture, Forestry and Fisheries (2015) that Japanese beef and hybridize type beef are differentiated from imported beef, but dairy beef competes with imported beef. Furthermore, with regard to hybridize type beef, which has not been explicitly analyzed in previous research, the results support the conclusion that the development and expanded production of this beef has been greatly effective as a countermeasure to the past liberalization of beef imports.

On comparing the above estimation results of the demand structure for beef with the results of Mori and Lin (1990), they are the same on the point that there is no competitive relationship between Japanese beef and imported beef, but they differ on the point that there is a competitive relationship between dairy beef and imported beef, and it is understood that this study more accurately captures the actual situation after the tariffication in 1991. The difference between these results implies that there is a possibility that bias is created in the estimation result of the demand structure

for beef when the non-stationarity of the time series data is not taken into consideration.

On the other hand, comparing the results to those of Matsuda (2014), 0.093, which is the value of the elasticity of demand for domestically produced beef to the price of imported beef estimated in Matsuda (2014), is a value in between 0.053 and 0.469, which are the elasticities of demand for the three classes of domestically produced beef to the price of imported beef estimated in this study. In other words, even though the degree of the substitution relationship with imported beef is different for each of the three classes of domestically produced beef, if all domestically produced beef are aggregated as one item, the estimation results in its average value; so it can be confirmed once again that it is necessary to disaggregate domestically produced beef into classes when estimating the demand structure for beef in Japan from the viewpoint of analyzing the impacts of the TPP Agreement.

7. Analyzing the Impacts of the TPP Agreement

1) The analysis method

In this section, the impacts of the TPP Agreement will be analyzed using the price elasticities of demand estimated in Section 5.

The following method is used for the analysis. First, when the demand function of item i $D_i=D_i(p_1,\cdots,p_8,y,DM_2,\cdots,DM_{12})$ is totally differentiated, the following equation can be obtained.

$$dD_i=\sum_{k=1}^{8}\frac{\partial D_i}{\partial p_k}dp_k+\frac{\partial D_i}{\partial y}dy+\sum_{s=2}^{12}\frac{\partial D_i}{\partial DM_s}dDM_s \quad (4)$$

Here, D_i is the quantity demanded for item i, and y is income.

Next, assuming that only the prices of imported meats change, using the price elasticities of demand, Equation (4) can be approximated as the following.

$$\Delta D_i=\eta_{i4}\frac{\overline{D}_i}{\overline{p}_4}\Delta p_4+\eta_{i6}\frac{\overline{D}_i}{\overline{p}_6}\Delta p_6+\eta_{i8}\frac{\overline{D}_i}{\overline{p}_8}\Delta p_8 \quad (5)$$

Here, $\Delta D_i\,(=D_{it}-D_{it-1})$ is the amount of change in the quantity demanded for item i, $\Delta p_k\,(=p_{kt}-p_{kt-1})$ is the amount of change in the price of item k, η_{ik} is the elasticity of demand for item i to the price of item k, period $t-1$ is the period before the TPP Agreement came into effect, and period t is the period after the TPP Agreement came into effect.

When approximating a differential by difference, it is necessary to use the mean value of before and after the change as levels values, so $\overline{D}_i$ and $\overline{p}_k$ are respectively expressed as follows.

$$\overline{D}_i=\frac{D_{it}+D_{it-1}}{2} \quad (6)$$

$$\overline{p}_k=\frac{p_{kt}+p_{kt-1}}{2} \quad (7)$$

Therefore, arranging Equation (5) using Equation (6) and Equation (7), the amount of change in quantity demanded ΔD_i due to the TPP Agreement can be expressed as follows.

$$\Delta D_i=\frac{\frac{\eta_{i4}}{\overline{p}_4}\Delta p_4+\frac{\eta_{i6}}{\overline{p}_6}\Delta p_6+\frac{\eta_{i8}}{\overline{p}_8}\Delta p_8}{1-\frac{\eta_{i4}}{2\overline{p}_4}\Delta p_4-\frac{\eta_{i6}}{2\overline{p}_6}\Delta p_6-\frac{\eta_{i8}}{2\overline{p}_8}\Delta p_8}D_{it-1} \quad (8)$$

Also, Δp_k, which is the amount of change in the price of item k, is calculated as follows.

$$\Delta p_k=p_{kt-1}\frac{1+r_{1k}}{1+r_{2k}}-p_{kt-1} \quad (9)$$

Here, r_{1k} is the tariff rate of item k after the TPP Agreement came into effect, and r_{2k} is the tariff rate of item k before the TPP Agreement came into effect.

In this study, the impacts of the TPP Agreement are analyzed using the analysis method described above. For the amount of changes in the quantity demanded for each item, the delta method is used to calculate its standard error, and whether these amounts are statistically significant is tested.

As the analysis scenario, based on the contents of the TPP Agreement, it is assumed that the respective tariff rates will be reduced or eliminated, with the beef tariff rate being reduced from 38.5% (temporary rate) to 9.0%, the pork tariff rate from 4.3% (temporary rate) to 0.0%, and the chicken tariff rate from 11.9% (WTO bound rate) to 0.0%.[13] From these reductions, the imported beef price will be reduced by 21.3%, the imported pork price by 4.1%, and the imported chicken price by 10.6%.[14] In other words, the quantity demanded of (from) the 16th year after the TPP Agreement came into effect, when the tariff reduction and elimination period for all the imported meats ends, is analyzed.[15]

Furthermore, to consider the triggering of the quantity safeguard for imported beef, the value of the quantity demanded for imported beef is calculated not just for the 16th year after the TPP Agreement came into effect, but also for the first year.[16] In the first year after the TPP Agreement came into effect, the beef tariff rate will be 27.5%, the pork tariff rate will be

13) Please refer to the Cabinet Secretariat (2016) for details on the contents of the TPP Agreement.

Table 7. The estimated marketing quantity of each of the meats from January to December in 2014 (benchmark of quantity demanded)

(Unit: 10 thousand tons)

	Japanese beef	Hybridize type beef	Dairy beef	Imported beef	Domestically produced pork	Imported pork	Domestically produced chicken	Imported chicken
Estimated marketing quantity	16.099	8.079	10.646	50.634	88.618	78.793	106.670	45.123

2.2%, and the chicken tariff rate will be 9.9%. Because of these reductions, the imported beef price will be reduced by 7.9%, the imported pork price by 2.0%, and the imported chicken price by 1.8%.

A total of estimated marketing quantities from January to December in 2014, which is shown in Table 7, is used as the benchmark for the quantity demanded for each of the meats.[17)]

2) Results of the analysis

The analysis results of the impacts of the TPP Agreement are shown in Table 8.

First, focusing on the changes in the quantity demanded for each of the imported meats, the changes in the quantities demanded for imported pork and imported chicken are not estimated to be significant, so it cannot be said that the TPP Agreement will have a significant impact on the demand for these imported meats. Conversely, the quantity demanded for imported beef will be increased significantly by 26.7%. Therefore, it is considered that beef is the meat whose imports will be increased the most by the TPP Agreement.

Second, focusing on the triggering of the quantity safeguard for imported beef, the criterion for triggering will be 59 ten thousand tons in the first year and 73.8 ten thousand tons in the 16th year after the TPP Agreement came into effect. With regards to this, the quantity demanded for imported beef will be 54.910 ten thousand tons in the first year and 64.134 ten thousand tons in the 16th year after the TPP Agreement came into effect, so it is forecasted that the import quantity of beef will not exceed the criterion for triggering the quantity safeguard.

Third, focusing on the changes in the quantities demanded for each of the domestically produced meats, the changes in the quantities demanded for Japanese beef, hybridize type beef, domestically produced pork, and domestically produced chicken are not estimated to be significant, so it cannot be said that the TPP Agreement will have a significant impact on the demand for these domestically produced meats. Conversely, the quantity demanded for dairy beef will be decreased significantly by 8.6%. Therefore, it is considered that dairy beef is the domestically produced

14) For the pork tariff, in the TPP Agreement, after maintaining the gate-price system and its gate-price of 524 yen/kg, the specific tariff in the low-price band will be reduced from a maximum of 482 yen/kg to a maximum of 50 yen/kg, and the ad valorem tariff in the high-price band of 4.3% will be eliminated. On this point, the Ministry of Agriculture, Forestry and Fisheries (2015) assumed that for pork imports in the future, combination imports will be likely to continue, but the possibility that some low-price cuts would be imported irrespective of the combination cannot be denied. Therefore, although it is difficult to accurately forecast the movement in the imported pork price after the TPP Agreement came into effect, in this study, it is assumed that the combination imports at gate-price will be continued, or in other words, the ad valorem tariff of 4.3% will be eliminated and the imported pork price will be reduced by 4.1%.

Also, for the chicken tariff, in the TPP Agreement, all the tariff, the whole chicken (not cut in pieces) tariff of 11.9%, the meat with bone (legs with bone in) tariff of 8.5%, and the other (boneless meat, etc.) tariffs of 11.9%, will be eliminated. The chicken import in 2014, the percentage of import quantity from countries joining the TPP Agreement out of the total import quantity was 5.4% (mainly meat with bone from the United States), and most of the imports are boneless meat from Brazil. Based on this point, the Ministry of Agriculture, Forestry and Fisheries (2015) expected that the impact of the TPP Agreement would be limited for chicken, but on the other hand, in the long-term, they are concerned that the price of domestically produced chicken will be reduced due to the changes of the import partner countries resulting from the tariff reduction or elimination, etc. Therefore, although it is difficult to accurately forecast the movement in the price of imported chicken after the TPP Agreement came into effect, in this study, the possibility that the import partner countries will be changed by the TPP Agreement is taken into consideration, and it is assumed that the tariff for boneless meat, which is currently the main imported item, of 11.9% will be eliminated and the imported chicken price will be reduced by 10.6%.

In addition, for beef imports, the percentage of import quantity from countries joining the TPP Agreement out of the total import quantity was 99.9% (2014), and for pork imports, the percentage of import quantity from countries joining the TPP Agreement out of the total import quantity was 62.0% (2014).

Table 8. Analysis results of the impacts of the TPP Agreement

(Unit: 10 thousand tons, %)

Meat	Change in the quantity demanded due to the TPP Agreement	Percentage change	Quantity demanded after the TPP Agreement came into effect
Japanese beef	−0.922 (−1.397)	−5.7	15.177
Hybridize type beef	0.025 (0.067)	0.3	8.104
Dairy beef	−0.911 ** (−2.258)	−8.6	9.735
Imported beef	13.501 ** (2.393)	26.7	64.134
Imported beef (first year)	4.276 ** (2.521)	8.4	54.910
Domestically produced pork	−1.456 (−0.679)	−1.6	87.162
Imported pork	7.190 (1.635)	9.1	85.983
Domestically produced chicken	2.792 (0.987)	2.6	109.462
Imported chicken	7.356 (1.514)	16.3	52.478
All domestically produced beef	−1.808～−0.911	−5.2～−2.6	33.016～33.913
All beef	11.693～12.590	13.7～14.7	97.151～98.048

Notes: 1) With regard to change in the quantity demanded due to the TPP Agreement, the upper row shows the estimated value and the lower row in parentheses shows the t value.

2) The critical value of the t distribution in the degrees of freedom for demand system of 307 is 1.650 at the 10% level, 1.968 at the 5% level, and 2.592 at the 1% level. Also, *, **, and *** indicate that the estimated value is statistically significant at the 10% level, 5% level, and 1% level, respectively.

3) With regards to all domestically produced beef (Japanese beef, hybridize type beef, and dairy beef) and all beef (Japanese beef, hybridize type beef, dairy beef, and imported beef), the values are calculated for both cases, totaling only the significant amounts of changes due to the TPP Agreement and totaling all the amounts of changes, including the non-significant amounts of changes.

4) The changes in the quantity demanded for each item are the values in the 16th year after the TPP Agreement came into effect. However, for imported beef (first year), it is the value in the first year after the TPP Agreement came into effect.

5) The change in the quantity demanded and the percentage change are the values based on the quantity demanded of the benchmark.

15) After the TPP Agreement came into effect, the tariff reduction and elimination period shall end on the 16th year for beef, the 10th year for pork, and the 11th year for chicken.

16) The tariff rate for imported beef will be reduced in the first year after the TPP Agreement came into effect from 38.5% to 27.5%, and then it will be reduced in stages from the second year onwards, to 20.0% in the 10th year and to 9.0% in the 16th year. Conversely, the criterion for triggering the quantity safeguard for imported beef will be 59 ten thousand tons (this quantity is a 10% increase from the actual import quantity in recent years) in the first year after the TPP Agreement came into effect, and then it will be increased in stages from the second year onwards, to 69.6 ten thousand tons in the 10th year, and to 73.8 ten thousand tons in the 16th year. In other words, both the tariff rate and the criterion for triggering the quantity safeguard for imported beef will be changed greatly in the first year after the TPP Agreement came into effect, and then it will be gradually changed from the second year onwards. Therefore, when considering the triggering of the quantity safeguard for imported beef, it is considered appropriate to focus on the quantity demanded for imported beef in the first year and the 16th year after the TPP Agreement came into effect.

17) In the analysis method used in this study, because $\frac{\Delta p_k}{\bar{p}_k}$ in Equation (8) is equal to $\frac{2(r_{1k}-r_{2k})}{2+r_{1k}+r_{2k}}$ and is a constant regardless of the price level, there is no need to set a benchmark for price.

meat that will be most affected by the TPP Agreement.

Fourth, focusing on the changes in the quantity demanded for all domestically produced beef (Japanese beef, hybridize type beef, and dairy beef), on the one hand, the changes in the quantities demanded for Japanese beef and hybridize type beef are not estimated to be significant, but on the other hand, the change in the quantity demanded for dairy beef is estimated to be significant. Considering both cases, totaling only the significant changes in the quantities demanded and totaling all the changes, including the changes in the quantities demanded that are not significant, we find that the quantity demanded for all domestically produced beef will be decreased by 2.6～5.2%.

Fifth, focusing on the changes in the quantity demanded for all beef (Japanese beef, hybridize type beef, dairy beef, and imported beef), although the quantity demanded for all domestically produced beef will be decreased by 2.6～5.2%, the quantity demanded for imported beef will be increased by 26.7%, so we find that the quantity demanded for all beef will be increased by 13.7～14.7%.

3) Sensitivity analysis

The above analysis is carried out based on the assumption that the price elasticities of demand do not change after this. However, the possibility that these elasticities will change in the future cannot be denied. Therefore, a sensitivity analysis is performed below regarding changes in the impacts of the TPP Agreement accompanied with changes in the price elasticities of demand.

First, when the percentage change (%) in the quantity demanded for item i due to the TPP Agreement is set as θ_i, and θ_i^m, which is the said percentage change when all the price elasticities of demand for item i become m (>0) times, can be expressed as follows.[18)]

$$\theta_i^m = \frac{200m\theta_i}{200+(1-m)\theta_i} \qquad (10)$$

Here, as shown in Table 8, the maximum value of θ_i, which is the percentage change in the quantity demanded due to the TPP Agreement, is 26.7% for imported beef, and the changes in price elasticities of demand are expected to be less than 8.5 times, so it can be said that the sign of the denominator in Equation (10) is constantly positive. Also, the sign of the numerator in Equation (10) is constantly the same as the sign of θ_i. Therefore, even when all the price elasticities of demand for item i become m times, the sign of Equation (10), or in other words the direction of the change, does not change.

Conversely, when the percentage change in quantity demanded for item i is set as θ_i and the percentage change in quantity demanded for item k is set as θ_k, if the relationship between them is $\theta_i > \theta_k$ and the signs of $200+(1-m)\theta_i$ and $200+(1-m)\theta_k$ are constantly positive, the relational expression of $\frac{200m\theta_i}{200+(1-m)\theta_i}$ $(=\theta_i^m) > \frac{200m\theta_k}{200+(1-m)\theta_k}$ $(=\theta_k^m)$ can be derived. Therefore, even when all of the price elasticities of demand for item i and item k become m times, the order of changes in the quantity demanded for item i and item k does not change.

In the results of the sensitivity analysis, if there are no changes in the direction and order of the changes, it is said that the results of the original simulation are robust.[19)] Therefore, it can be concluded that the analysis results of the impacts of the TPP Agreement, which were described in the previous subsection, are robust.

Incidentally, Table 9 shows the calculation results of the percentage changes in the quantities demanded when all the price elasticities of demand for both dairy beef and imported beef, whose estimation results of the impacts due to the TPP Agreement are significant in Table 8, become 0.8 times or 1.2 times. We see that the quantity demanded for dairy beef will be decreased by 6.9～10.2%, and the quantity demanded for imported beef will be increased by 20.8～32.9%.

4) Impact on the domestic production of beef

Based on the analysis results described above, the

18) When all the price elasticities become m times, the amount of change in quantity demanded for item i due to the TPP Agreement of ΔD_i^m can be expressed as follows.

$$\Delta D_i^m = \frac{\frac{m\eta_{i4}}{\bar{p}_4}\Delta p_4 + \frac{m\eta_{i6}}{\bar{p}_6}\Delta p_6 + \frac{m\eta_{i8}}{\bar{p}_8}\Delta p_8}{1-\frac{m\eta_{i4}}{2\bar{p}_4}\Delta p_4 - \frac{m\eta_{i6}}{2\bar{p}_6}\Delta p_6 - \frac{m\eta_{i8}}{2\bar{p}_8}\Delta p_8} D_{it-1}$$

Here, arranging Equation (8) using the relational expression $\theta_i = \frac{\Delta D_i}{D_{it-1}} \times 100$ and $\theta_i^m = \frac{\Delta D_i{}^m}{D_{it-1}} \times 100$, Equation (10) can be obtained.

19) Hosoe *et al.* (2016) was referred to.

Table 9. Results of the sensitivity analysis with regard to the price elasticity of demand

(Unit: %)

Meat	Percentage change in quantity demanded (price elasticity 0.8 times)	Percentage change in quantity demanded (standard)	Percentage change in quantity demanded (price elasticity 1.2 times)
Dairy beef	−6.9 [80.7]	−8.6 [100.0]	−10.2 [119.0]
Imported beef	20.8 [77.9]	26.7 [100.0]	32.9 [123.3]

Notes: 1) The values in the table are the percentage changes in quantity demanded when all the price elasticities of demand for dairy beef and imported beef become 0.8 times or 1.2 times.
2) The respective values in the [ ] parentheses are the indexed values when the standard percentage change in quantity demanded is set as 100.

Table 10. Transition in the production quantity of domestically produced beef and import quantity of beef (fiscal 1990 to fiscal 2000)

(Unit: 10 thousand tons)

Fiscal year	Production quantity of domestically produced beef			Import quantity of beef	Total beef
	Total	Japanese beef	Dairy-type beef		
1990	37.803 [100.0]	13.543 [100.0]	24.260 [100.0]	38.548 [100.0]	76.351 [100.0]
1991	39.629 [104.8]	14.313 [105.7]	25.317 [104.4]	32.686 [84.8]	72.316 [94.7]
1992	40.729 [107.7]	15.055 [111.2]	25.674 [105.8]	42.339 [109.8]	83.068 [108.8]
1993	40.658 [107.6]	15.960 [117.8]	24.697 [101.8]	56.687 [147.1]	97.345 [127.5]
1994	41.392 [109.5]	17.370 [128.3]	24.022 [99.0]	58.396 [151.5]	99.788 [130.7]
1995	40.634 [107.5]	17.299 [127.7]	23.335 [96.2]	65.836 [170.8]	106.469 [139.4]
1996	37.747 [99.9]	16.666 [123.1]	21.081 [86.9]	61.121 [158.6]	98.868 [129.5]
1997	36.376 [96.2]	16.933 [125.0]	19.443 [80.1]	65.893 [170.9]	102.269 [133.9]
1998	36.472 [96.5]	16.841 [124.4]	19.630 [80.9]	68.176 [176.9]	104.648 [137.1]
1999	37.412 [99.0]	16.869 [124.6]	20.542 [84.7]	68.257 [177.1]	105.668 [138.4]
2000	36.088 [95.5]	16.394 [121.0]	19.694 [81.2]	73.837 [191.5]	109.925 [144.0]

Notes: 1) The total for production quantity of domestically produced beef indicate the total of the production quantity of Japanese beef and dairy-type beef (hybridize type beef and dairy beef). Also, total beef indicates the total of the production quantity of Japanese beef and dairy-type beef, and import quantity of beef.
2) All of the values are a cut meat basis, and the values in the [ ] parentheses are the respective indexed values when the value of fiscal 1990 is set as 100.

impact of the TPP Agreement on the domestic production of beef will be considered.

First, in the results of the analysis shown in Table 8, looking at all domestically produced beef, imported beef, and all beef, although there are differences in degree, it is considered that the changes after the TPP Agreement came into effect will show the same tendency as the changes after the tariffication of beef imports in April 1991. As shown in Table 10, from fiscal 1990 to fiscal 2000 (the year prior to the domestic outbreak of bovine spongiform encephalopathy (BSE)), the production quantity of all domestically produced beef had decreased by 4.5%, but on the other hand, the import quantity of beef had increased by 91.5%, and as a result, the total amount of the production quantity of domestically produced beef and import quantity of beef had increased by 44.0%.

On the other hand, in the results of the analysis shown in Table 8, looking at domestically produced beef by class, it is considered that the changes after the TPP Agreement came into effect will show a different tendency than the changes after the tariffication of beef imports. As shown in Table 10, from fiscal 1990 to fiscal 2000, the production quantity of all domestically produced beef had decreased by 4.5%, which was because the production quantity of dairy-type beef (hybridize type beef and dairy beef) had decreased by 18.8%, but the production quantity of Japanese beef had increased by 21.0%. In the case of aiming to increase the production of Japanese beef, also after the TPP Agreement came into effect, it is considered that an important point on the demand side is whether demand for Japanese beef has the characteristics of a luxury good. But after comparing the estimation results

in this study to the previous research, it seems that the characteristics of an essential good have been strengthened in the demand for Japanese beef since the tariffication of beef imports.[20] In other words, it can be said that the current situation is that it is more difficult to increase the production of Japanese beef compared to the situation after the tariffication of beef imports. Therefore, even though the production quantity of Japanese beef had recovered from fiscal 2004 (13.272 ten thousand tons) to fiscal 2012 (16.684 ten thousand tons) to the level of before the BSE outbreak, it is considered that we cannot expect a further increase in production after the TPP Agreement came into effect.

8. Conclusion

In this study, based on the present-day concerns in Japan about the impact of the TPP Agreement on the domestic production of beef, after econometrically clarifying the current demand structure for beef in Japan, the impact of the TPP Agreement on the domestic production of beef was considered. When analyzing the demand structure for beef, to overcome the problems in previous research, the estimation was carried out using a demand system model after disaggregating the beef into four classes—Japanese beef, hybridize type beef, dairy beef, and imported beef—and in addition, taking into consideration the non-stationarity of time series data. The results of the analysis revealed the following points.

First, regarding the time series data of Japan's meat, it is considered that most of the original series are unit root processes, and all the data become stationary processes by taking the first difference from one period before. Also, looking at the demand system as a whole, there is no co-integration relationship among the time series data for Japan's meats.

Second, in Japan, the responses of demand for imported meats are larger than those for domestically produced meats with respect to own price and meat expenditure.

Third, it cannot be said that the TPP Agreement will have significant impacts on the quantities demanded for domestically produced pork, imported pork, domestically produced chicken, and imported chicken.

Fourth, it cannot be said that the TPP Agreement will have significant impacts on quantities demanded for Japanese beef and hybridize type beef; on the other hand, the quantity demanded for dairy beef will be decreased by 8.6%. In addition, the quantity demanded for all domestically produced beef will be decreased by 2.6～5.2%, but the quantity demanded for imported beef will be increased by 26.7%, and as a result, the quantity demanded for all beef will be increased by 13.7～14.7%.

Fifth, after the tariffication of beef imports in 1991, the impact of trade liberalization had been mitigated because of compensating for the decrease in production of dairy beef etc. by the increase in production of Japanese beef. However, the same mitigation effect cannot be expected after the TPP Agreement came into effect.

Finally, the future issues in this study are as follows. Due to the data constraints, it was not possible to analyze the impact of the Great East Japan Earthquake or relaxing the age limitation of beef produced in the United States on the demand structure for beef in Japan. Also, in the analysis of the impacts of the TPP Agreement, the point that supply-side factors, including exports, were not considered remains as an issue. To analyze the impacts of the TPP Agreement more accurately, it will be necessary to overcome these issues and perform a more detailed analysis in the future.

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20) In Mori and Lin (1990) (analysis period: Q2 1978 to Q1 1988), the meat and fish expenditure elasticity of demand for Japanese beef was estimated to be 2.55, which indicated that Japanese beef was estimated as a luxury good. Also, in Matsuda (2014) (analysis period: January 1994 to March 2011), the meat expenditure elasticity of demand for domestically produced beef was estimated to be 0.812. Conversely in this study (analysis period: January 2006 to February 2011), the meat expenditure elasticities of demand are estimated to be 0.408 for Japanese beef, 0.280 for hybridize type beef, and 0.406 for dairy beef. These differences imply that from the tariffication of beef imports to the present time, the meat expenditure elasticity of demand for Japanese beef has become smaller.

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