Demand for quality-differentiated beef in Japan

Die Nachfrage nach qualitätsdifferenziertem Rindfleisch in Japan

Sayed H. Saghaian and Michael R. Reed
University of Kentucky, Lexington, USA

Abstract

In this article, we apply a model of vertical product differentiation to the Japanese beef market. We theoretically derive a system of consumer demand functions for quality-differentiated beef in Japan. We choose a particular utility function which is nonlinear in the consumption of the quality-differentiated product and linear in the consumption of all other goods. We employ a seemingly unrelated econometric model to estimate Japanese consumer demand functions for four beef types from the four origins. The empirical results show Japanese consumers prefer domestically produced beef to imported US and Australian. We also find seventeen substitution and two complementary effects among the various origins.

Key words

vertical quality differentiation; consumer demand; beef; Japan

Zusammenfassung

In diesem Beitrag wenden wir ein Modell der vertikalen Produktdifferenzierung auf den japanischen Rindfleischmarkt an. Wir leiten theoretisch ein System von Nachfragefunktionen für qualitätsdifferenziertes Rindfleisch ab. Die zugrunde liegende Nutzenfunktion ist nichtlinear im Konsum des differenzierten Gutes und linear im Konsum aller anderen Güter. Wir verwenden ein SUR (seemingly unrelated regression)-Modell, um die Nachfragefunktionen für vier Rindfleischtypen aus vier Herkünften zu schätzen. Die empirischen Ergebnisse zeigen, dass japanische Verbraucher heimisches Rindfleisch gegenüber Importen aus den USA und Australien bevorzugen. Darüber hinaus finden wir siebzehn signifikante Substitutions- und zwei Komplementärbeziehungen zwischen den verschiedenen Herkünften.

Schlüsselwörter

vertikale Produktdifferenzierung; Qualitätsdifferenzierung; Verbrauchernachfrage; Rindfleisch; Japan

1. Introduction

Nowhere in the world is quality heterogeneity in food products more important than in Japan, where consumers have very discriminating tastes and are willing to pay very high prices for high-quality food. Quality differentials are especially apparent and important to Japanese beef consumers (HAYES et al., 1990). Survey results have shown that Japanese consumers have strong preferences for quality in beef and can readily identify different qualities of beef in the market (KHAN et al., 1990). The Japanese beef market is mainly made up of four different types: two domestic types, wagyu and dairy, and two imported types, from the US and Australia. These beef types are specifically identified at retail outlets by type of beef for domestic cuts (wagyu is specifically identified) and country-of-origin labeling on imports. In most stores, domestic and imported beef cannot be displayed in the same case, so consumers clearly know the origins of their beef purchases. The quality and retail beef prices by country of origin, and by type of domestically produced beef, vary widely in the Japanese market (LONGWORTH, 1989).

Among these four beef origins in 1999, Australian beef had the highest overall market share for chilled muscle cuts, accounting for 30.8% of the Japanese market. They were followed by Japanese dairy beef (26.1%), Japanese wagyu beef (21.6%), and US beef (21.3%). The chuck, clod, and round cuts accounted for the highest market share (60%) in 1999. This category of cut was followed by loin (21.1%) and rib (19.0%). For 1999, there were substantial quantities of each beef cut supplied from all origins. The cut/origin combination with the largest market share in 1999 was Australian chucks (including clods and rounds) with 19.9%, while the cut/origin with the smallest market share was wagyu ribs with 3.0%. All of these data came from the LIVESTOCK INDUSTRY PROMOTION CORPORATION (LIPC) (various issues).

Japanese consumers consider wagyu to be the highest quality beef. Japanese dairy beef is considered to be lower in quality than wagyu, yet higher than imported US grain-fed beef. Domestic beef is viewed as much more fresh than imported beef and this is a major consideration in purchasing decisions (KHAN et al., 1990). Japanese consumers perceive Australian grass-fed beef to be the lowest quality beef. Wagyu beef and high-quality cuts of Japanese dairy beef are characterized as the so-called "super beef". The prime wagyu beef is well marbled and is generally used for traditional beef dishes such as *sukiyaki, shabu-shabu,* or other variants collectively known as *nabemono*. The marbling and texture of wagyu beef allows its use in these dishes; other beef types are much less desirable for these cooking techniques. Figure 1 shows the large monthly retail price differences among these four beef types for the specific loin cut during the 1992:01-1999:07 period.

Traditionally fish was the main source of animal protein in the Japanese diet. Beef was not considered a substitute for fish fifty years ago because of culture, eating habits, and cooking methods. As social structures changed and real per-capita income increased, consumers gradually accepted beef and its consumption grew faster than any other meat. Per-capita consumption increased from 4.1 kg in 1986 to reach 7.7 kg in 1996. Japanese beef consumption hit 542 800 metric tons in April-September 2000, up 3.2% from the total reached over the same period in 1999. Forecasts suggest that the growth in beef consumption will continue, reaching between 9.6 and 11 kg per capita by 2005 (MAFF, various issues).

The way beef dishes are served has a great impact on the Japanese beef market. In 1991, 48% of the beef consumed

in Japan was eaten in the home while 42% was consumed through the foodservice market. By 1996, the picture had changed considerably with only 41% eaten at home and 50% in the foodservice sector. A MAFF survey shows that of the beef eaten at home in 1996 over 80% was domestically produced Japanese beef compared to just 60% in 1994. However, the opposite is the case in the foodservice sector where imported beef accounts for over 90% of the market, up from 70% in 1993.

In this article, we apply a model of vertical product differentiation to the Japanese beef market. The contributions of this study are twofold. First, we theoretically derive a system of consumer demand functions for quality-differentiated beef in Japan, based on the general substitute model of SPENCE (1976) and DIXIT and STIGLITZ (1977). Second, the theoretical derivations of consumer demand functions are the basis for our empirical work. We employ a seemingly unrelated econometric model to estimate Japanese consumer demand functions for four beef types: chuck, loin, ribs, and round, from the four origins. The empirical results indicate high Japanese consumers' preference for domestically produced beef types and lend support to non-price quality competition.

2. Literature review

Products differ with respect to many attributes. These products with varying attributes, which are developed to satisfy individual variations in tastes and preferences, are said to have different varieties. These varieties of a given product have either real or perceived differences in their characteristics. The assumption is that individuals consider themselves to be better off or have a higher utility when they can exercise choice by having various combinations of goods from which to choose.

There are two families of product differentiation models: models of horizontal differentiation and those of vertical differentiation. In models of horizontal product differentiation, each product will have a positive market share when all the varieties are offered at the same price. The most utilized models within this category are the location, or HOTELLING-type, models. In those models, consumers are uniformly distributed on a preference scale and are characterized by the distance from their location to that of their ideal product. HOTELLING (1929) first studied this type of product differentiation, which LANCASTER (1979) later labeled horizontal differentiation.

In models of vertical product differentiation, varieties of products are ranked by quality. The defining characteristic is that all consumers have the same ranking of product variants so if two product varieties are offered at the same price, all consumers prefer the same one – the one with the higher quality. Consumers only differ in their willingness to pay for quality. GABSZEWICZ and THISSE (1979) and SHAKED and SUTTON (1982) considered this approach, which LANCASTER (1979) labeled vertical differentiation.

Product differentiation has attracted wide attention (SPENCE, 1976; DIXIT and STIGLITZ, 1977; MUSSA and ROSEN, 1978; LANCASTER, 1979; GABSZEWICZ and THISSE, 1979; PERLOFF and SALOP, 1985 and 1986; SHAKED and SUTTON, 1982; HELPMAN and KRUGMAN, 1985; ANDERSON et al., 1989; FEENSTRA and LEVINSOHN, 1989; MOTTA, 1993; ETHIER, 1994; BRESNAHAN, 1981, among others). However, despite increasing interest in studying product differentiation and consumer behavior in such markets, most studies focus on the theoretical rationale and ramifications of product differentiation. The body of empirical research is much smaller. As farmers and agribusinesses are encouraged to pursue value-added production to improve their competitiveness, they need information on the returns to developing vertically differentiated products.

Three general approaches are used to formulate consumer demand for differentiated products: non-address, address, and logistic. The studies that have used the above approaches focus on horizontal product differentiation. In the non-address approach, consumer preferences for differentiated goods are defined over a predetermined set of all possible goods, which is either finite or countable infinite. It is called the goods-are-goods or the non-address branch (SHAPIRO, 1989). These models are generally associated with CHAMBERLIN's monopolistic competition model (1933). Diversity of consumer demand for differentiated goods stems from the consumer's desire to consume all varieties (the love of variety). A representative consumer captures the aggregated preferences for differentiated goods (SPENCE, 1976; DIXIT and STIGLITZ, 1977).

In those monopolistic models, it is usually assumed that there are a large number of products available in a market. Product demand is derived from utility maximization by a representative consumer with a strictly quasi-concave utility function: $u = U(x_0, V(x_1, x_2, x_3, \ldots))$, where x_0 is the quantity of a composite commodity and x_i is the quantity of the i^{th} product. Prices are normalized and cost functions are usually product-specific. Since a representative consumer purchases every product in these models, each product competes with every other product (CHAMBERLIN's symmetry assumption).

In contrast to the non-address approach, competition among products in a market is localized in the address approach. Consumer preferences are generally assumed to be distributed over some continuous space of parameters or variables. Because of differences in consumer tastes or other factors, such as differences in individual consumers' incomes, different consumers have different preferred products (ideal products) or locations (geographic points). In a geographic location model, products are located on a line or on the circumference of a circle, which denotes dispersion. Products in HOTELLING's (1929) original "linear city" model were homogeneous products, but differed in traveling costs for an individual consumer to purchase them.

In LANCASTER's (1979) characteristic model, it is assumed that there is an infinite spectrum of potential products, of which only a finite number are actually available. Utility is obtained from consuming characteristics embedded in the product. Consumers who consume the available products that are not their ideal products suffer penalties in term of costs or utility. Individual consumer demand is derived from a two-stage consumer decision process: 1) which product to buy and 2) how much to buy (HELPMAN and KRUGMAN, 1985). In the first stage, a compensation function is used to determine a point where a consumer is indifferent if either of the two adjacent available products (to the left or right of his/her most preferred) is purchased. The boundary points for a product are the two indifference points on both

sides of that product. Consumers falling within the interval definitely buy that product and thus consumers who buy a product are identified.

The logistic approach is based on the discrete choice theory developed in econometrics and was used in PERLOFF and SALOP's (1985) probabilistic choice model. This model is sometimes called a hybrid of the address and non-address models because it starts with differences in consumer preferences and ends with each product competing with every other product in a market. In this approach, an infinite number of products are assumed, but only a finite number of them are available in the market.

Vertical product differentiation

The three approaches described have generally focused on horizontal product differentiation. To formulate consumer demand under vertical product differentiation, it is no longer valid to assume that consumer preferences for quality are different. Alternatively, it is normally assumed that consumers have common agreement on ranking of quality-differentiated products. Every consumer prefers high-quality products to low-quality products. Diversity of consumer demand arises from differences in other factors, such as consumer income (GABSZEWICZ and THISSE, 1979; SHAKED and SUTTON, 1982). Market demand functions for the quality-differentiated products generally possess the same properties as the characteristic models. Yet, consumers with different incomes have different ideal quality products due to differences in willingness to pay for quality. They purchase the available product that is the closest one to their ideal product. Therefore, competition among quality-differentiated products is also localized, as in the address approach.

Empirical studies in differentiated products.

Only a few studies attempt to empirically estimate consumer demands for differentiated products, despite a rich body of theoretical literature on product differentiation. BRESNAHAN (1981) derived a vertically differentiated product demand system and empirically analyzed the extent of departure from marginal-cost pricing in the American automobile industry. Consumer preferences were assumed to be uniformly distributed with a constant density. Diversity of consumer demands came from differences in consumers' sumers' tastes, not from consumer incomes. Given auto prices, boundary points could be determined from the condition that consumers with the same tastes were indifferent between buying either of two neighboring autos with different qualities. Thus, consumers within the taste interval would only buy a particular model, the one that maximizes their utility.

(1)

FEENSTRA and LEVINSOHN (1989) extended BRESNAHAN's (1981) one-dimensional quality-differentiated model into a multi-characteristic model to study the competition among auto producers in an oligopolistic framework. Ideal products (combination of characteristics) were derived from utility maximization and determined by taste parameters. The indirect utility function was used to identify consumers with ideal products (a particular model of car). They empirically estimated neighbor models by determining the indifference points, which are midpoints of lines drawn between pairs of models. Consumer demand functions were then empirically estimated along with an optimal oligopolistic pricing equation.

3. The theoretical model

Economists commonly use the Almost Ideal Demand System and the Rotterdam models to estimate demand systems. This is due to the fact that these models are not only compatible with demand theory, but also have flexible functional forms and are easy to estimate. For examples of these studies and their applications see ALSTON and CHALFANT (1993). However, these models are not quite applicable to vertically differentiated products where non-price competition (including variations in styling and quality) is practiced.

The model of consumer behavior we use is a special form of a general substitute model introduced by SPENCE (1976), and DIXIT and STIGLITZ (1977). SPENCE (1976) suggested the general form for the benefit function to be u (x) = $G\left[\int \phi_i(x_i)di\right]$ where G and ϕ_i were concave functions. If u (x) has the form u (x) = $\left[\int_i a_i x_i^{\beta}\right]^{\theta}$, then it has the form of a CES function. DIXIT and STIGLITZ (1977) assumed a separable utility function with convex indifference surfaces: u (x) = $U(x_0, V(x_1, x_2, x_3\ldots))$, where V is the subutility derived from consumption of differentiated products x = (x_1, x_2, $x_3\ldots$) and u (x) is the upper-tier utility function representing the overall welfare level. They further simplified V to be a symmetric function and considered two special cases: (1) V was given a CES form, but U was allowed to be arbitrary: u (x) = U $\left(x_0, \left\{\sum_i x_i^{\rho}\right\}^{1/\rho}\right)$. (2) U was taken to be Cobb-Douglas but V had a general additive form: u (x) = $x_i^{1-\gamma}\left\{\sum_i V(x_i)\right\}^{\gamma}$, subject to the budget constraint $x_0 + \sum_i^n p_i x_i = I$.

In this research, we choose a general functional form of the two product model by SINGH and VIVES (1984), and HÄCKNER (2000):[1]

where x_i is the quantity of differentiated product i and x_0

$$U(x_0, x) = x_0 + \sum_{i=1}^{n} x_i \alpha_i - \frac{1}{2}\left(\sum_{i=1}^{n} x_i^2 \beta_i + 2\sum_{i=1}^{n} \sum_{j=1|j\neq i}^{n} x_i x_j \lambda_{ij}\right)$$

is all other goods. Hence, the second and third terms in equation (1) represent a special form for V, the subutility function of differentiated products in the general substitute model by SPENCE (1976), and DIXIT and STIGLITZ (1977). HÄCKNER (2000) argues that this utility function allows for two dimensions of product heterogeneity: vertical product differentiation and substitutability. The parameter α_i measures quality in a vertical sense. Other things equal, an increase in α_i increases the marginal utility of consum-

[1] We are indebted to an anonymous reviewer for insights into the theoretical model and its use in interpreting the empirical results.

ing product *i*. The λ_{ij} s can be used to measure the substitutability between the differentiated products: positive λ_{ij} s imply goods are substitutes, while negative λ_{ij} s imply they are complements. HÄCKNER (2000) argues that when goods are substitutes, the degree of substitutability could be interpreted in terms of horizontal product differentiation. In this model, the conditions for perfect substitution between good *i* and good *j* are: $\beta_j = \lambda_{ij} + \lambda_{ji}$, $\beta_i = \lambda_{ji} + \lambda_{ij}$, and $\lambda_{jk} + \lambda_{kj} = \lambda_{ik} + \lambda_{ki} \forall\ k \in [1;n \backslash \{i;j\}]$.

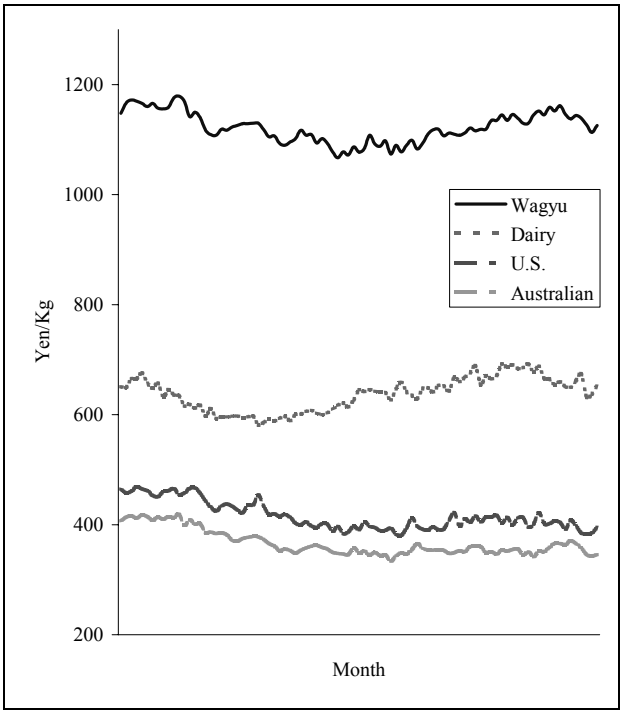
The representative consumer maximizes utility subject to the budget constraint, $\sum p_i x_i + x_0 = I$, where *I* denotes income and the price of the composite good x_0 is normalized to one. Differences among consumers are ignored; all demand functions are considered to be proportional to those of a typical or standard consumer who maximizes utility defined over all commodities consumed. The first-order condition determining the optimal consumption of product *i* is:

$$(2) \quad \frac{\partial U(x_0, x)}{\partial x_i} = \alpha_i - x_i \beta_i - \sum_{j=1 | j \neq i}^{n} (\lambda_{ij} + \lambda_{ji}) x_j - p_i = 0$$

where p_i is the price of product *i*. From the first-order conditions, one can solve for the inverse demand function for product *i*. These inverse consumer demand functions form a system of simultaneous equations, which is the basis of our empirical work.

Because of beef quality differentials in Japan, strong consumer preferences in beef quality, reflected in terms of marbling, freshness, and color, contribute to a wide range of retail prices (figure 1). In this case, as argued by THEIL and SUHM (1981), quality is summarized by means of one single number - price. Since high quality beef commands higher costs than low quality beef, the average price that a family pays for a unit of quality-differentiated beef is representative of beef quality. This view is consistent with empirical results from hedonic regressions where more product attributes generally lead to higher consumer prices. This literature maintains that price is the best measure of product quality (GRILICHES, 1971). However, the use of price as a cue or signal for quality has also shown to have theoretical implications with mixed empirical results (e.g., HJORTH-ANDERSON, 1991; ZEITHAML, 1988).

Figure 1. Japanese Monthly Retail Prices of Beef Loin by Type for the 1992:01-1999:07 Period



Source: MAFF

4. Data description

The model is applied to chilled beef cuts (chuck, loin, ribs, and round) in the Japanese market. Monthly data for the period 1992:02 to 1999:07 were collected. Data for the retail prices of chilled US and Australian beef cuts in yen per 100 grams were taken from LIPC (various issues) publications. US and Australian beef imports were also taken from the LIPC and are measured in metric tons. The original source of these data is MAFF: "Meat Marketing Statistics", Japan's Ministry of Finance, "Japan Exports and Imports". Imports are assumed to equal consumption because information on stocks is not available.

The data for quantities of Japanese wagyu and dairy beef and their retail prices were taken from AGRICULTURAL AND LIVESTOCK INDUSTRIES CORPORATION (ALIC) (2001). There are no data available prior to February 1992. This source only provides monthly (and calendar year) carcass weight of wagyu and dairy beef produced in Japan. Domestic consumption by type and cut is not available.

We used USDA guidelines to calculate the amount of beef chuck, loin, ribs, and round produced from these carcasses. In general, a 1000-pound steer yields 615 pounds of beef (61.5% of the live weight) to retailers. The retailer trims away 183 pounds of fat, bone, and waste to end up with 432 pounds of retail beef cuts. Of these retail cuts, 134.3 pounds are salable chuck, 77.7 pounds are salable loin, 47.5 pounds are salable ribs, and 83.8 pounds are salable round. We assume that all wagyu and dairy beef loin produced in Japan is domestically consumed.

5. Econometric model and diagnostics

The theoretical model serves to guide the specification of the empirical demand system for quality-differentiated beef consumed in Japan. Equation (2) shows that each of the four endogenous variables representing consumer inverse demands for wagyu, dairy, US, and Australian beef cuts are linearly related to the quantity of beef varieties consumed as a system of simultaneous equations. The empirical model for the inverse demand system for each beef cuts is given by (3):

$$(3) \quad \begin{aligned} Pw_t &= \alpha_w - \beta_w Qw_t - \lambda_{wd} Qd_t - \lambda_{wu} Qu_t - \lambda_{wa} Qa_t + \varepsilon_w \\ Pd_t &= \alpha_d - \beta_d Qd_t - \lambda_{dw} Qw_t - \lambda_{du} Qu_t - \lambda_{da} Qa_t + \varepsilon_d \\ Pu_t &= \alpha_u - \beta_u Qu_t - \lambda_{uw} Qw_t - \lambda_{ud} Qd_t - \lambda_{ua} Qa_t + \varepsilon_u \\ Pa_t &= \alpha_a - \beta_a Qa_t - \lambda_{aw} Qw_t - \lambda_{ad} Qd_t - \lambda_{au} Qu_t + \varepsilon_a \end{aligned}$$

where *w, d, u,* and *a* subscripts denote wagyu, dairy, US, and Australian beef, respectively, and *t* indexes time. Note that each λ_{ij} in the empirical model of equation (3) repre-

sents the sum ($\lambda_{ij} + \lambda_{ji}$) from equation (2) of the theoretical model. Thus, the coefficients of the Q_j s in the empirical model are an abbreviation for the complex sum-coefficients of each x_j in the equation (2). The interpretation of these estimated coefficients is complex and is not pursued in this paper. Also, note the cross prices are not present in this model; competition in vertically differentiated products hinges on quality rather than price. SHAKED and SUTTON (1982) find that vertical product differentiation relaxes price competition.

This demand system is identified with respect to the order and rank conditions of identification. In this model, contemporaneous correlation across equations renders traditional ordinary least-squares estimates unbiased and consistent, but inefficient. Hence, we estimate the unknown structural parameters of the model by using the seemingly unrelated regression (SUR) routine, because its estimates are more efficient than the OLS estimates, and account for heteroskedasticity between equations and contemporaneous correlation in the residuals. The estimates of the cross-equation covariance matrix are based upon parameter estimates of the un-weighted system.

Various diagnostic tests were performed to make sure that the empirical techniques used were valid. All Durbin-Watson *d* statistics, after correction for autocorrelation, using the AR(1) model in EVIEWS, exceed the upper limit critical value in the bounds test, indicating first-order serial correlation does not exist at the five-percent level. Also, we failed to reject the null hypothesis that the residuals were normally distributed at the five-percent level of significance when using the standard Jarque-Bera test statistic. Thus, the empirical residuals from the final structural model maintained the necessary theoretical properties to ensure the integrity of our statistical inferences and hypothesis testing. Finally, note that the empirical model derived in equation (3) has some negative signs. However, the results presented in the tables are from the estimation of a model without use of negative signs; we have reported the signs in the table as they were estimated. Hence, a negative coefficient on own-quantity (β) means that the demand curve is downward sloping and a negative coefficient on cross-quantity (λ_{ij}) shows a substitution relationship.

6. Empirical results

Analyses of consumer demand for quality-differentiated products are hindered by the lack of appropriate data and empirical testing. Furthermore, few attempts have been made to address the demand for food products in vertically differentiated markets, or non-price competition among product varieties with vertical attributes. This study has developed a model of vertical product differentiation and has applied the model to the Japanese beef market, which is mainly made up of four quality-differentiated types: domestically produced wagyu and dairy and imported US and Australian for four beef cuts (chuck, loin, ribs, and round). Based on the theoretical derivation, a simultaneous equation econometric model of Japanese beef demand for the four beef types was constructed by using monthly data for the period 1992:02-1999:07 period.

The empirical results for beef chuck

As can be seen from table 1, the empirical results for chuck show that all αs are significantly different from zero and have positive signs. These estimated coefficients indicate that Japanese consumers rank wagyu as having the highest quality chuck, followed by dairy, US, and Australia. Wagyu chuck sells for a 64% premium over dairy chuck; dairy chuck sells for a 65% premium over US chuck; and US chuck sells for a 12% premium over Australian chuck. All of these differences are significantly different from zero at the 5% level, except for the US/Australia difference. Clearly, Japanese consumers prefer domestically produced chuck to the imports. Estimated inverse demand coefficients (βs) are negative and statistically different from zero for wagyu, dairy, and Australian chuck. The estimated inverse demand coefficients are small, which means that the actual demand curves are highly elastic.

Several substitution coefficients (λs) are statistically significant. The results show λs for wagyu-dairy; dairy-wagyu, US-dairy, and Australian-US are significantly different from zero. These estimated coefficients have negative signs indicating that they are substitutes; dairy chuck is substituted for wagyu and wagyu chuck for dairy, dairy chuck is substituted for US chuck; and US chuck is substituted for Australian chuck. The estimated values are small but, as indicated before, an interpretation of the magnitude of these substitution effects is complicated and beyond the scope of this paper.

Table 1. Point estimates of parameters in the econometric model for chuck

Wagyu	α_w =566.39	β_w =-0.005	λ_{wd} =-0.006	λ_{wu} =0.002	λ_{wa} =0.000
	(41.72)***	(-3.02)**	(-2.09)**	(1.16)	(0.006)
R^2	67%				
Durbin-Watson	2.07				
Dairy	α_d =345.73	β_d =-0.001	λ_{dw} =-0.004	λ_{du} =0.001	λ_{da} =-0.000
	(40.40)***	(-2.33)*	(-2.23)*	(0.47)	(-0.13)
R^2	54%				
Durbin-Watson	1.95				
U.S.	α_u =210.23	β_u =-0.001	λ_{uw} =0.000	λ_{ud} =-0.001	λ_{ua} =-0.001
	(18.47)***	(-0.44)	(0.08)	(-2.51)*	(-1.35)
R^2	77%				
Durbin-Watson	2.03				
Australian	α_a =186.81	β_a =-0.000	λ_{aw} =0.000	λ_{ad} =-0.001	λ_{au} =-0.004
	(15.29)***	(-2.52)*	(0.31)	(-0.42)	(-2.20)*
R^2	82%				
Durbin-Watson	2.26				

Note: t-statistic values are in parentheses. ***=1%, **=5%, and *=10% significance level.
Source: authors' computations

The empirical results for beef loin

The results for the α parameters did corroborate the obvious superiority of wagyu and dairy beef loin evident from the price chart (figure 1). All αs are highly significantly different from zero and all the estimated coefficients are positive (table 2). The α parameter plays a crucial role in this analysis, measuring quality in a vertical sense (as α increases for a product, so does the marginal utility of that product). The quality ranking is the same as for chuck: wagyu, dairy, US, and Australian. All of the differences are significantly different from zero at the 5% level, except the US/Australia difference. The results are similar to those for chuck: wagyu loin enjoys a 75% premium over dairy loin; dairy loin enjoys a 56% premium over US loin; and US loin has a 16% premium over Australian loin. Domestically produced beef loin is clearly preferred to imported beef.

Table 2. Point estimates of parameters in the econometric model for loin

Wagyu	α_w =1107.93	β_w =-0.012	λ_{wd} =0.003	λ_{wu} =-0.005	λ_{wa} =0.000
	(58.95)***	(-2.39)**	(0.49)	(-1.62)*	(0.09)
R^2	88%				
Durbin-Watson	1.82				
Dairy	α_d =632.68	β_d =-0.001	λ_{dw} =-0.006	λ_{du} =0.009	λ_{da} =-0.003
	(24.15)***	(-0.08)	(-1.02)	(2.48)**	(-0.83)
R^2	88%				
Durbin-Watson	1.99				
U.S.	α_u =406.14	β_u =-0.002	λ_{uw} =-0.003	λ_{ud} =0.008	λ_{ua} =-0.003
	(21.10)***	(-0.77)	(-0.56)	(1.09)	(-1.00)
R^2	86%				
Durbin-Watson	1.95				
Australian	α_a =348.52	β_a =-0.000	λ_{aw} =0.003	λ_{ad} =-0.006	λ_{au} =0.004
	(22.13)***	(-0.07)	(0.93)	(-1.25)	(1.92)*
R^2	93%				
Durbin-Watson	1.88				

Note: t-statistic values are in parentheses. *** =1%, ** =5%, and * =10% significance level.
Source: authors' computations

The results show the inverse demand coefficient (β) of wagyu is statistically different from zero at the 5-percent level. Other estimated inverse demand coefficients have the expected negative signs, indicating consumers are facing downward sloping demand curves, but they are statistically insignificant. All own-quantity coefficients are small in absolute value, which shows the demand curves are elastic.

The results of the estimations for the λs indicate there are three significant linkages among the beef loin origins; all involving the US. The cross-quantity effects that are significantly different from zero are the wagyu-US with a negative sign and the dairy-US, and Australia-US cross effects (in one direction) with positive signs, meaning some US beef loin is substituted for wagyu, and there exits some complementary relationship between US and dairy and US and Australian beef loin.

The empirical results for beef ribs

The empirical results for beef ribs shown in Table 3 again indicate that Japanese consumers rank domestic beef higher than imported beef. All the αs are highly significantly different from zero with the expected positive signs and the estimated coefficients ordered by value (from highest to lowest) are wagyu, dairy, US, and Australian, respectively. However, the premiums are different than for chuck or loin, especially for US beef. Wagyu ribs have a 50% premium over dairy ribs, but dairy ribs have only a 2% premium over US ribs. Further, US ribs have a wide premium (82%) over Australian ribs. All of the differences are significantly different from zero at the 5% level, except the US/dairy difference. US ribs are commonly used as an ingredient in the Japanese "beef bowl" chains, a style of restaurant that saw rapid sales growth during the 1990s in Japan (REED and SAGHAIAN, 2004).

The estimated inverse demand coefficients (βs) all have negative signs, indicating downward-sloping demand curves, and are significantly different from zero for wagyu, dairy, and Australian cuts. The substitution coefficients (λs) are significantly different from zero for wagyu-US, wagyu-Australian, dairy-US, dairy-Australian, and US-Australian ribs. All these coefficients have negative signs, which means some of the US and Australian imported ribs are substituted for domestically produced wagyu and dairy ribs. This two-way substitute relationship is significant for wagyu-US and wagyu-Australian (wagyu ribs are substituted for US and Australian ribs and vice versa).

The empirical results for beef round

The empirical results for beef round also show Japanese consumers have a higher preference for domestically produced beef in contrast to imported US and Australian beef. The αs in table 4 are all significantly different from zero with higher estimated values for wagyu and dairy compared to US and Australian round. The premiums for the beef types were similar to the results for chuck and round: wagyu round has a 51% premium over dairy round; dairy round has a 67% premium over US round; and US round has a 20% premium over Australian round. All of the differences are significantly different from zero at the 5% level, except the US/Australia difference.

The estimated inverse demand coefficients (βs) have negative signs, but all are statistically insignificant. The estimated substitution coefficients (λs) show a two-way relationship between US and wagyu, and US and dairy round (US round is substituted for wagyu and dairy, and vice versa). The results also show that some US round is substituted for Australian round (but this is a one-way substitution only).

7. Summary and conclusions

The empirical results show consistently that Japanese consumers prefer domestic wagyu and dairy beef to imported US and Australian. These results clearly show that by Japanese consumers' preferences and standards, domestically

Table 4. Point estimates of parameters in the econometric model for ribs

Wagyu	α_w =457.67	β_w =-0.009	λ_{wd} =0.015	λ_{wu} =-0.006	λ_{wa} =-0.009
	(26.58)***	(-1.79)*	(1.56)	(-2.04)**	(-2.39)**
R^2	88%				
Durbin-Watson	2.01				
Dairy	α_d =305.96	β_d =-0.003	λ_{dw} =-0.002	λ_{du} =-0.004	λ_{da} =-0.003
	(12.22)***	(-2.56)**	(-0.87)	(-1.60)*	(-1.68)*
R^2	91%				
Durbin-Watson	2.18				
U.S.	α_u =299.45	β_u =-0.002	λ_{uw} =-0.005	λ_{ud} =0.006	λ_{ua} =-0.004
	(21.08)***	(-1.02)	(-2.77)**	(0.73)	(-1.11)
R^2	44%				
Durbin-Watson	1.96				
Australian	α_a =163.78	β_a =-0.001	λ_{aw} =-0.005	λ_{ad} =-0.006	λ_{au} =-0.004
	(13.05)***	(-2.39)**	(-1.92)*	(-1.25)	(-1.94)*
R^2	75%				
Durbin-Watson	2.15				

Note: t-statistic values are in parentheses. *** =1%, ** =5%, and * =10% significance level.
Source: authors' computations

Table 3. Point estimates of parameters in the econometric model for round

Wagyu	α_w =570.67	β_w =-0.002	λ_{wd} =0.003	λ_{wu} =-0.002	λ_{wa} =0.001
	(36.67)***	(-1.00)	(0.63)	(-1.85)*	(1.13)
R^2	77%				
Durbin-Watson	2.05				
Dairy	α_d =377.97	β_d =-0.004	λ_{dw} =-0.001	λ_{du} =-0.001	λ_{da} =-0.007
	(93.11)***	(-1.07)	(-0.58)	(-2.48)**	(-0.11)
R^2	79%				
Durbin-Watson	2.01				
U.S.	α_u =226.87	β_u =-0.003	λ_{uw} =-0.004	λ_{ud} =-0.009	λ_{ua} =0.001
	(9.30)***	(-1.42)	(-1.68)*	(-1.97)**	(1.36)
R^2	92%				
Durbin-Watson	2.04				
Australian	α_a =188.65	β_a =0.001	λ_{aw} =0.001	λ_{ad} =0.002	λ_{au} =-0.003
	(10.71)***	(1.28)	(0.97)	(0.60)	(-2.19)**
R^2	93%				
Durbin-Watson	2.04				

Note: t-statistic values are in parentheses. *** =1%, ** =5%, and * =10% significance level.
Source: authors' computations

produced beef is considered as higher quality when compared to imported beef. Wagyu had more than a 50% premium over dairy for all cuts, dairy had at least a 50% premium over US for all cuts except ribs, and the US had a 10-20% premium over Australian for all cuts except ribs. Japan has a higher valued use for US ribs, reducing the discount to dairy ribs to only 2% and increasing the premium over Australian ribs to 80%.

All of the competitors in the Japanese market have at least one beef type with a negatively sloped inverse demand function, except for the US. There were three such demand functions for wagyu and two such demand functions for dairy and Australian cuts. In all of these cases, the elasticity was quite small in absolute value. In addition, we found that there were mostly substitution effects among beef types (wagyu, dairy, US and Australian), except for beef loin that showed some complementary effects.

The results are generally consistent with those of HAYES et al. (1990) though their beef categories were somewhat aggregated. They found some net substitutability between an aggregate wagyu beef and an "import-quality beef," which included both aggregate quality imports and domestic dairy beef. They also rejected the hypothesis that those beef types were perfect substitutes. Yet one must be skeptical of many past empirical models based on the results presented here. Japanese demand for beef is very specific with respect to cut and origin, so models that aggregate cuts and especially origins are making assumptions about substitutability that are not supported by this analysis.

Given these facts, an appropriate strategy for the US and Australia, the two main suppliers of imported beef to Japan, is to increase quality and advertising to promote their beef in Japan in order to overcome the stigma of "imported beef". They cannot emulate the quality of wagyu beef and these imported cuts are often viewed as inferior to domestic dairy beef. KHAN et al. (1990) have argued that younger Japanese have a preference for leaner, imported beef and that as their disposable incomes grow, beef imports will increase. Further, if the importers can develop specialized uses for their beef that are popular with Japanese consumers and that capitalize on their beef characteristics (as the US has with the use of its rib cuts in the beef bowl restaurants); they will differentiate their beef products in a positive manner.

The US and Australia should not count on increased exports to Japan simply because wagyu and dairy supplies are dwindling. Japanese consumers must be convinced that imported beef can meet the requirements of traditional cooking methods used for domestic beef, particularly wagyu. With promotional and educational programs and product quality developments by US and Australian cattle feeders, and Japanese demographic changes, the long-run prospects for imported beef could improve. Both the US and Australia have launched campaigns to promote their beef products in Japan (ACKERMAN, 1993).

One challenge that the US in particular will face is the acceptance of its beef after the outbreak of bovine spongiform

encephalopathy (BSE) in the US. At this writing, US beef exports to Japan are banned because of the BSE outbreak. These food safety problems with US beef will likely further differentiate it from other suppliers, so US exporters will need to work hard to overcome this stigma. The data series analyzed in this study did not include data during the outbreak, but this occurrence will obviously have serious and potentially long-run consequences on US beef exports to Japan.

Future analyses of beef demand in Japan and possibly other countries will need to incorporate more detailed data in their analysis. Each beef cut and origin have different uses in the cooking styles of the importing country. There is substitutability among cuts and origins in some cases, but certainly not all. Without a disaggregated analysis that can identify these differences, empirical models of beef and other meat trade will not have the detail necessary to understand these important markets.

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Corresponding author:
PROF. DR. MICHAEL R. REED
Department of Agricultural Economics, University of Kentucky,
308 Charles E. Barnhart Building
Lexington, KY 40546-0276, USA
phone: +(1)-859-257 72 59, fax: +(1)-859-257 72 90
e-mail: mrreed@uky.edu