ESSAYS ON MAKING DECISIONS ON TRADE QUANTITIES, GROWING NEW CROPS IN OKLAHOMA, AND SELECTING A DEMAND FUNCTIONAL FORM

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This thesis consists of three papers. In the first paper, the utility maximization model is developed to determine optimal quantities for several beef types exporting to Japan by incorporating risk attitude of decision-maker and uncertainty into the decision framework. In the second paper, the simulation method used will provide farmers with information about the risk/reward tradeoffs involved in growing new alternative crops versus growing traditional crops in Oklahoma. In the third paper, the Monte Carlo method is constructed to select between two most popular demand system (AIDS and Rotterdam). The validity of demand assumptions (weak separability and demand restrictions), when the incorrect functional form is used, are also examined.

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TABLE OF CONTENTS

Chapter Page

Chapter Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

Chapter I

Incorporating Risk in Making Decisions about Trade Quantities: A Case of Retail Cut Beef Exports to Japan

ABSTRACT

Econometric models are commonly used to forecast demand for agricultural commodities. Typical econometric models include the criterion and predictor variables as well as an error term that is supposed to capture the effects of all variables that affect the criterion variable but are not explicitly included in the model. Therefore, the error term in these models represents the variance in the criterion variable not explained by the model. Because the error term is random and unknown, it is a source of risk. Generally, risk tolerance level varies from person to person. Therefore, a decision made on a more risky forecast that may be optimal for a risk-preferring decision-maker may not be optimal for a risk-averse decision-maker. Thus, the objective of this study is to obtain optimal quantities that would give the decision-maker the highest utility by taking into account the uncertainty of unexplainable variation excluded from econometric model. The results showed that the amount of each beef type that a decision-maker would be willing to trade differs according to his/her risk attitude. Risk-averse decision-makers prefer less volatile commodities, even if it means lower profits, while risk-seeking decision-makers prefer higher profit commodities, even if it means higher risk.

Introduction

My ventures are not in one bottom trusted,
Nor to in one place; nor is my whole estate
Upon the fortune of this present year:
Therefore, my merchandise makes me not sad.
("The Merchant of Venice", Act I, Scene 1)

In his book "Against the Gods: The Remarkable Story of Risk," Peter Bernstein argues that the notion of bringing risk under control is a central idea that distinguishes modern industrialized times from the non-industrialized past. He points out that development of innovative risk management techniques during the seventeenth century was largely responsible for the success of maritime trade by the European nations. Goods, which once had been considered scarce, such as sugar, spice, coffee, tea, and raw cotton, were shipped daily from colonies and suppliers around the world. Because goods had to be shipped over long distances, investors depended on information and judgements about consumer needs, pricing levels, and fashions to forecast demand. Consequently, forecasting became a vital part for entrepreneurs who were willing to take the risk of international trade (Bernstein, 1996).

For hundreds of years, scholars have been developing theories and methods to forecast the future. Trends in historical data are used to make projections about the future. Generally, the technique of regression analysis is used for this purpose. "Regression analysis refers to the techniques used to derive an equation that relates the criterion variable to one or more predictor variables" (Churchill 1991, p.823). The predictions based on regression analysis are not perfect. One reason for this is that certain predictor variables, which are not known to the researcher, are not explicitly included in the regression equation and are only represented by the error term. This error term is a source of random variation and, hence, risk in the forecast. Moreover, most decision-makers do not know how to incorporate risk in their forecasts (Fisher, Hammond, Obermeyer and Raman, 1994). Thus, an objective of this study is to incorporate demand uncertainty from the effects of the unknown variables into the decision-making framework.

Additionally, any decision-making framework should include the risk preference of the decision-maker because the optimality of any risky decision will depend on the risk preference of the decision-maker. As researchers have pointed out, rational people process information objectively, subject to their preferences (Bernstein). In other words, the level of risk associated with a decision that may be optimal for a risk-seeking person may be non-optimal for a risk-averse person. Thus, a risk averse person may not make the same decision as a risk preferring person (Hammond, 1967). Therefore, a second objective of this study is to incorporate the risk attitude of the decision-maker into the decision framework.

Japanese demand for beef

In this study, the case of Japanese demand for beef is used to illustrate the importance of incorporating demand uncertainty and the risk preference of the decision-maker into the decision framework.

The Japanese beef import market is vitally important to American beef exporters; this is evidenced by the numerous studies that have been done on this topic. In the past, this market was very highly protected by the Japanese government using import quotas. Under the system the Japanese Livestock Industry Corporation played the role of the middleman in that it controlled the quantity, quality and type of beef imported into Japan. Thus, the type of beef imported into Japan was determined not by consumer preference, but by the rules set up by the Livestock Industry Corporation. For instance, Japanese consumers prefer chilled beef to frozen beef but frozen beef was mainly imported to Japan (Kerr et. al., 1994, p. 1). The reason for this was that the quota system did not allow direct shipment from foreign beef processors to retailers in Japan. Therefore, it was not feasible to export the highly perishable chilled beef to Japan. However, in 1988 the Japanese government signed the Beef Market Access Agreement with the U.S., and, consequently, the quota system was removed in 1991. Beef exporters must now deal directly with the retailers in Japan, hence, they are now subject to exporting what the Japanese consumers demand (Kerr et. al., 1994, p. 1).

While the lifting of quotas has many advantages for the exporters, they are also faced with a more risky situation in trying to cater to the vagaries of the Japanese consumer preferences. The U.S. exporter must now decide how much of the different types of beef to export to meet Japanese consumer needs. The risk in this situation mainly arises from the uncertainty of demand for different types of beef.

Sources of Risk in the Export Decision

There are several sources of risk in making the export decision. For instance, providing the Japanese consumers their preferred chilled beef, as opposed to frozen beef, is more risky in that it has a much shorter shelf life (60 days) than frozen beef. As shown in Figure 1, the total time of shipment from U.S. to Japan is 27 to 28 days, so that gives the Japanese retailers only 32-33 days to sell the product (Semi, 1990, p. 129). Between the time that the decision to export the beef is made and when the product is available in the Japanese market, the price may have fluctuated making it unprofitable or less profitable for the exporter to sell the beef. If frozen beef was shipped then it can be stored for a longer period and sold when the price level becomes more suitable to the exporter. However, if chilled beef is shipped then, given its relatively short shelf life, the exporter has no option but to sell even at the lower price.

The Decision Situation U.S. Exporters Face

As indicated earlier, beef traders have to make decisions regarding how much of different types of beef (rib, loin, chuck etc.) to be shipped to Japan. Kerr et al. convincingly argue that, in Japan, the rate of growth of sales of each type of beef product, along the quality continuum (higher quality versus lower quality cuts) is not likely to be equal, consumption of some types will increase faster than others. Also, the relative market share of the different types of beef is likely to shift over time. The quantity and type of beef consumed in Japan is seasonal (Kerr, et. al., 1994 ,p. 163). Different dishes are prepared at different times throughout the year (Khan, Ramaswami, and Sapp, p. 40). In addition, income and price elasticities vary across different types of beef. For instance, slowing economic growth is expected to have a greater effect on the demand for more expensive as compared with less expensive (Khan, Ramaswami, and Sapp, p. 13). On the other hand, the demand for less expensive beef is more inelastic to income and price (Khan, Ramaswami, and Sapp, 1990). Although, the more expensive types of beef have a higher profit margin, demand for them is more elastic (as compared to cheaper types) and inability to sell them leads to higher losses. Also, the expensive types of beef are demanded by Japanese buyers in chilled rather than frozen state, thus, making them more perishable. As discussed earlier, due to the 27-28 day time required for transporting beef from the U.S. to Japan, the exporters must decide the quality and quantity of beef to be exported much before the exact market demand for these products can be known. Therefore, good forecasting methods are needed to minimize exporter losses.

Existing Methods of Making Export Decisions

Research shows that while a large number of methods could be used to forecast market developments in Japan, the two most often used methods (after import liberalization) are armchair speculations and econometric modeling. While academicians favor advanced statistical techniques, most business people are more likely to use the armchair speculations method which is based on the forecaster using his/her experience to forecast future market conditions (Kerr et al.,1994). The accuracy of the armchair method varies with the ability and experience level of the forecaster. However, in general, given the complexity of the Japanese beef market, especially after import liberalization, it is very difficult to use this method to make accurate forecasts. Generally, armchair speculation works well when the market is simple and the market conditions are stable (Kerr et al.,1994).

The second forecasting technique, econometric modeling, is generally used by academic researchers. This technique is based on consumer theory. It requires long and consistent sets of data to achieve statistical reliability. However, even with this technique, it is not possible to predict demand with complete certainty even when the parameter estimates are known. This inability to predict is due to the imperfection in measuring explanatory variables included in model and the random effect of the variables that are not included in the demand model (Raman and Chatterjee, 1995). The decision-makers that have to deal with short lifecycle products (like chilled beef) should incorporate demand uncertainty into their production-planning processes models.

The attempt to incorporate demand uncertainty into decision making regarding beef exports raises several questions that need to be answered. First, how should one estimate the demand uncertainty for each beef product? Second, what methodologies should one use for incorporating demand uncertainty into trade decisions? Finally, assuming that different traders have varying attitudes toward risk, how to maximize a trader's expected utility? Note that while this study uses beef as a case in point, the methodology used here could also be used for estimating the optimal export mix for other similar agricultural commodities.

Objective

The general objective of this study is to incorporate demand uncertainty and risk attitude into the decision framework. The steps involved in achieving this objective are as follows:

1. Estimate demand for a commodity (beef) and its sub-categories in Japan using existing demand models.
2. Determine the probability distribution of demand uncertainty due to the variables excluded from the demand model (the demand uncertainty due to the effects of the excluded variables is represented by the error term in the model).
3. Use the demand uncertainty estimated from the previous step to determine the quantities of beef subcategories that maximize the decision-maker's expected utility given his risk attitude.

Literature Review

To incorporate risk in a decision, one must include the probability information regarding the distribution of the random event. One method of doing this incoporation is to use the expected utility maximization framework (Preckel and DeVuyst, 1992). Note that, the reason expected utility is used instead of expected profit is the relevant criterion for decision-making was based on the probability distribution of expected income not the expected income itself (Schilizzi and King, 1999). Using the expected utility maximization framework, Dhrymes (1964) studied the optimal mix of output for a multiproduct firm. He assumed that firms have to determine output level of each product before the actual demand is known. However, the study dealt with a monopolistic situation. Similarly, Sandmo (1971) used the utility maximization framework to study the optimal output quantity for maximizing the utility of a single product firm in a competitive environment under conditions of price uncertainty. He also assumed that the decision regarding the output volume had to be taken before the sale date. Raman and Chatterjee (1995) incorporated uncertainty derived from the error term of the demand model into the utility maximization model. They suggested that when firms use a demand model the imperfect parameter estimates and the random impact of the variables excluded from the model result in a risky situation. Additionally, they used the utility maximization approach to obtain the optimal price path in a dynamic market. However, their study used a single demand equation to deal with a single product firm and they focused on a monopolistic case in which the firm could set its own price (as opposed to the price being determined via market competition) to deal with output demand uncertainty. The major difference between their study and the current study is that the current study examines a multiproduct firm in a competitive market situation. The main objective of this study is to find the optimal quantities for production of each product, for a multi-product firm, that yield highest expected utility given a risk preference.

Conceptual framework

The expected utility (EU) framework is widely used to choose between alternatives for decision making under risk. As stated earlier, in this study, we assume that firms have to make the decision about quantity of each product to produce before the actual price is known. In addition, the econometric model, rather than armchair forecasting, is assumed to be the tool that firms have used to predict future demand. Thus, the model used here is an inverse demand model that can be written as:

$\mathbf{P} = g\,(\mathbf{x}, \varepsilon)$;

where **P** is the vector price of output (restricted to be nonnegative), **x** is the vector of explainatory variables, and ε is the vector of disturbance terms. The objective of firms is assumed to be maximizing expected utility of profit. The firms' profit can be written as:

$$\pi(\mathbf{Q}) = \mathbf{PQ} - C(\mathbf{Q}) - B$$

where, **Q** is the vector of output, C (**Q**) is the variable cost function (assume $C\,(0) = 0$, and $C'(\mathbf{Q}) > 0$, and B is the fixed cost. The expected profits can be written as:

$$(1)\qquad E\,[u(\mathbf{PQ} - C(\mathbf{Q}) - \mathrm{B})],$$

where E is the expectation mathematical operation.

As suggested by Preckel and DeVuyst (1992), the function to be integrated is divided into the product of two functions, $\phi(x, y)$ and $f(x)$. The integral is written as:

$$(2)\qquad E[\phi(\mathrm{x}, \mathrm{y})] = \int\int,\ldots,\int \phi(\mathrm{x}, \mathrm{y})\, f(\mathrm{x})\mathrm{dx}_1\mathrm{dx}_2,\ldots,\mathrm{dx}_\mathrm{m}.$$

where x is a vector of m independent random variables which are represented by x_i, y is a vector of decision variables, $\phi(x, y)$ is a utility function, and $f(x)$ is the joint probability density functions for the random events. The common way to deal with multidimensional integration is using Monte Carlo integration (Kalos and Whitlock, 1986 and Geweke, 1994). This integral is approximated be the following steps:

a) Draw x_n randomly from its distribution with N replications

b) Calculate a set of utility function $\phi(x_n, y)$ by substituting each randomly drawn x_n into the utility function $\phi(x, y)$

c) The average of utility function are the approx. expected utility $E[\phi(x, y)] \approx \frac{1}{N}\sum_{1}^{N}\phi(x_n, y)$

Model

Generally, existing studies have examined the demand for aggregate commodities such as beef, pork, fish and poultry (For instance, Wahl, Hayes, and Williams, 1991; Yang and Koo, 1994; Hayes, Whales, and Williams, 1996; Comeau, Mittelhammer, and Wahl, 1997). However, the aggregate data are too broad for product-specific decision-making. Capps et al. (1994) used monthly data to estimate demand at the wholesale level in the U.S. for twelve types of beef. Capps et al. used a double logarithmic model. Deaton and Muellbauer (1980) suggested using the Linear approximation AIDS model because it is flexible, simple to estimate, to test, and to impose theoretical restrictions. Finally, it satisfies the consumer choice axiom (Alston and Chalfant, 1993).

An important assumption made in this study is that import quantities of goods are determined by exporters/importers based on consumer demand rather than government regulations. This assumption is one of the assumptions of the inverse demand model, which assumes that prices are adjusted after predetermined quantities are in the market. Note that inventory is not being considered because beef is a perishable product. Considering the advantages of AIDS model and the aforementioned assumptions, the Inverse Almost Ideal Demand System (IAIDS), suggested by Eales and Unnevehr (1994), is appropriate for this study.

The IAIDS model is written as follows:

$$(4) \qquad W_i = \gamma_i + \sum_j \gamma_{ij} \ln Q_j + \beta_i \ln I + \varepsilon_i$$

where W_i or P_iQ_i/Y is the budget share allocated to the i^{th} beef subcategory, P_j is the price of good j^{th}, Q_j is the quantity consumed of good j^{th}, Y is the per capita expenditure on beef, ε_i is disturbance term due to the demand uncertainty, ln I is the expenditure index. The Stone's quantity index, $\ln I = \sum W_i \ln Q_i$ suggested by Eales and Unnevehr (1993) is used in this study. As stated earlier, Japanese beef consumption is seasonal. Demand for different types varies throughout the year. The dynamic model can be used to measure the movement of the demand as follows:

$$(5) \; \Delta W_i = \alpha_i + \sum_j \gamma_{ij} \Delta \ln Q_j + \beta_i \Delta \ln I + \varepsilon_i$$

where Δ is the first-difference of the variables (W_i, $\ln Q_j$, and $\ln I$).

Adding up, homogeneity, and Slutsky symmetry are consequently written as follows:

(6) $\sum_{i=1}^{n}\gamma_i = 1$; $\sum_{i=1}^{n}\gamma_{ij} = 0$; and $\sum_{i=1}^{n}\beta_i = 0$;

(7) $\sum_{j}\gamma_{ij} = 0$; and

(8) $\gamma_{ij} = \gamma_{ji}$

The expected utility maximization framework can be written as follows:

$$(9)\ \underset{Q}{Max}\, E[u(\pi)] = \int\int,...,\int u(\sum_{i=1}^{n}\overline{P_iQ_i} - C(Q_{1,},Q_2,...,Q_n)f(\boldsymbol{\varepsilon})d\varepsilon_1 d\varepsilon_2,..d\varepsilon_n$$

subject to $\overline{P_iQ_i}$ and $\mathbf{Q} \geq 0$ where $\overline{P_iQ_i}$ is W_i, in equation (5) divide by Y.

where ε is the jointly distributed vector of random events, and $f(\varepsilon)$ is the joint probability density function for the random variables.

The AIDS model shown in equation (5) is usually estimated by a system of regression equations. Because the disturbance of each subcategory i is correlated, some data information might be lost if a separate equation is used in estimating the model (Greene, 1997, p. 649). Therefore, ε is considered the case of a jointly distributed random variable. The approximations of jointly distributed ε can be constructed by using a linear transformation as an approximation of the joint distribution[1] (Geweke, 1994).

Data and Estimation

The data used are the monthly data from Agriculture & Livestock Industries Corporation (Japan). This data contain prices and quantities for three types of beef: loin, chuck, and

[1] The multivariate normal random vector from the distribution N(μ, Σ), is generated as following. First draw z randomly from $\mathbf{z} \sim N(\mathbf{0}, \mathbf{I})$. Then, ε are calculated as $\varepsilon = \mu + \mathbf{Az}$ where $\mathbf{AA'} = \Sigma$. Generally, Cholesky decomposition, where $\varepsilon_{j\times 1}$ the diagonal elements of the upper or lower triangular **A** are positive, is used instead of **A** in equation $\varepsilon = \mu + \mathbf{Az}$.

rib eye. Therefore, profits can be calculated by subtracting retail prices of beef in Japan from beef export prices. Because of the elimination of the quota system in 1991, the most complete data range available after 1991 was used. The estimation period used is from January 1993 to December1998. In addition, the January to March 1999 data was used for comparison purpose. Furthermore, a commonly used utility function, the negative exponential utility function was used. The negative exponential utility function is written as $u(\pi) = -e^{r\pi}$. The Pratt-Arrow coefficient (*r*) is a constant where $r > 0$, $r = 0$ or $r < 0$ is specified for a trader who is risk averse, risk neutral or risk seeking. In this study, the five *r's* suggested by Larson and Mapp (1997) were used. Because the Pratt-Arrow coefficients used in Larson and Mapp were measured in dollars, the outcome may be affected when they are measured in Japanese yen. To solve the problem of different scaling, we used the transformation of scale for the Pratt-Arrow coefficient suggested by Raskin and Cocharan (1986). The Pratt-Arrow coefficients after transformation are: –0.000002 (risk seeking), -0.000001 (slightly risk seeking), 0.000001(slightly risk averse), 0.000003 (risk averse), and 0.000016 (extremely risk averse).

As mentioned earlier, there were three steps in obtaining the optimal quantities using the utility maximization procedure. First, equation (5) of the model was estimated using the seeming unrelated regression with the restrictions imposed (equations (6) to (8)). This step was completed by procedure SYSLIN with SUR available in the SAS program. Second, the Monte Carlo integration was conducted to obtain the approximate integral of equation (9). After this, we substituted the parameters estimated from the first step in equation (9). This left us with quantities that are the only non-numerical variables in the model. Then, further operations were conducted by the MATHEMATICA program, which allows algebraically calculations. The 10,000 replications of disturbance terms (ε) were drawn randomly from N (0,1) and transformed to multinomials using Cholesky decomposition. The summation of the transformed multinomials was the probability distribution of the disturbance term, ε. We expected the utility function to be a non-linear negative exponential function. The final step was to maximize the utility from the second step. To obtain the optimal quantities of each beef types while dealing with this non-linear utility function, we used the procedure NLP available in SAS. The upper and lower bounds for each quantity of past imports were the maximum plus 10 percent growth of the market and the minimum in that particular month.

Results

The assumptions underlying the multi-equation linear regression model-- normality, parameter stability, functional form, homoskedasticity, and independence--were examined. Then, the misspecification test suggested by McGuirk, Driscoll, Alwang, and Huang, 1994 was used to examine the alternative models such as static linear approximate AIDS (LA/AIDS), and static IAIDS. The results showed that appropriateness of the functional form and some of the linear regression assumptions did not hold for these two models. Thus, statistical problems may arise because of the structural change. Using static LA/AIDS or IAIDS, the dynamic of adjustment in demand may not be adequate for the model. The dynamics model such as a first-difference model is commonly used to deal with the problem (McGuirk et. al, 1994). Hence, we re-estimated the Japanese beef demand using a first-difference IAIDS and the first-difference AIDS. The results of the misspecification test suggested that all assumptions held at the 5% confidence level for first-difference IAIDS but not for LA/AIDS.

The parameters estimated from using the first-difference IAIDS model are shown in Table 1. All quantity coefficients were significant at the 1% confidence level. R^2 for loin, chuck, and rib eye equations are 0.85, 0.84 and 0.86. This indicates that about 80% of the budget share change over a year (ΔW_i) was explained by independent variables ($\Delta \ln Q_j$ and $\Delta \ln I$). Approximately less than 20% of the change was influenced by unknown variables. After substituting the parameters estimated from Table 1 in equation (9), the Monte Carlo integration was conducted. The Monte Carlo integration resulted in a utility function as a function of quantities.

The descriptive statistics for the three beef types (chuck, loin and rib eye) are shown in Table 2. Chuck had the highest average profit while rib eye had the lowest. Loin had the highest profit variability while rib eye had the lowest. Clearly, loin gave high but mostly unstable profits while rib eye gave the lowest but quite stable profits.

The decision-model in equation (9) was used to estimate the optimal quantities of each beef type that should have been exported to Japan during January 1999 to March 1999; this model takes into account the risk attitude of the decision-maker. The results are presented in Table 3. In January 1999, optimal quantities of beef that maximize the expected utility of the risk-seeking and slightly-risk-seeking decision-maker's were 6 metric tons of loin, 10.01 metric tons of chuck, and 3 metric tons of rib eye. The optimal quantities of beef that maximize the expected utility of the slightly-risk-averse, the risk-averse, and the extremely-risk-averse decision-maker's were 4 metric tons of loin, 11.53 metric tons of chuck, and 5 metric tons of rib eye. In February 1999, optimal quantities of beef that maximize the expected utility of the risk-seeking decision-maker were 6.5 metric tons of loin, 13.51 metric tons of chuck, and 4.16 metric tons of rib eye. The optimal quantities of beef for the slightly risk-seeking decision-maker were 6.5 metric tons of loin, 13.45 metric tons of chuck, and 4.21 metric tons of rib eye. Similarly, the optimal quantities of beef for the risk-averse and slightly-risk-averse decision-maker were 4.22 metric tons of loin, 16.0 metric tons of chuck, and 6.0 metric tons of rib eye. For the extremely-risk-averse decision-maker, the optimal quantities of beef were 4.41 metric tons of loin, 15.62 metric tons of chuck, and 6.0 metric tons of rib eye. In March 1999, the optimal quantities of beef for the risk-seeking decision-maker were 8 metric tons of loin, 11.64 metric tons of chuck, and 5.39 metric tons of rib eye; for the slightly risk-seeking decision-maker, they were 8 metric tons of loin, 13.37 metric tons of chuck, and 3.87 metric tons of rib eye. The slightly-risk-averse, the risk-averse, and the extremely-risk-averse decision-makers had the same optimal quantities of beef and they were 4.5 metric tons of loin, 16.53 metric tons of chuck, and 7 metric tons of rib eye.

The commodities that risk seekers prefer, are highly variable in demand as well as profit. Hence, risk seekers may gain more profit when the market demand for the riskier commodities is high. For instance, in February, moderate and slightly risk averse decision makers preferred chuck to loin but the extremely risk averse did not prefer this combination. Consequently, in this case, the extremely risk averse will gain less profit than the moderate and slightly risk averse decision-makers. The sensitivity frontier is shown in Figure 1. The optimal combination of the three beef types change with the risk attitude of decision-maker.

Conclusions

Fisher et al.(1994) stated that most of decision-makers do not know how to incorporate risk in their forecasts. Using the Japanese beef market as a case in point, we demonstrated that use of our decision model would allow decision-makers to incorporate their risk attitude into their decision framework and, hence, enhance their decision satisfaction. Specifically, we showed that the amount of each beef type that a decision-maker would be willing to trade differs according to his/her risk attitude. Risk averse decision-makers prefer less volatile commodities, even if it means lower profits, while risk-seeking decision-makers prefer higher profit commodities, even if it means higher risk. The utility maximization model developed in this study can be used to help decision-makers maximize their utility when allocating optimal quantities of different cuts of beef for trade. This model can also be used by multiproduct firms to make decisions regarding the optimal quantities of various products to be produced or traded.

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Table 1. The Parameter Estimates of the First-Difference IAIDS Model for Japanese Beef during January 1993 –December 1998

Commodity	Expenditure Coefficient	Quantity Coefficients			R^2
		Loin	Chuck	Rib eye	
Loin	0.0066	0.2588***	-0.1785***	-0.0803***	0.85
	(0.0058)	(0.0126)	(0.0114)	(0.0072)	
Chuck	-0.0091	-0.1785***	0.2574***	-0.0788***	0.84
	(0.0063)	(0.0114)	(0.0131)	(0.0066)	
Rib eye	0.0025	-0.0803***	-0.0788***	0.1591***	0.86
	(0.0033)	(0.0072)	(0.0066)	(0.0077)	

Note: Parenthesized numbers are standard errors. "***" denotes significant at 1% significance level.

Table 2. Descriptive Statistic of Profit for each Beef Type during 1993-1998

Period	Beef Type	Mean	Maximum (100 million yens)	Minimum	Standard Deviation
January:	Loin	12.89	15.24	10.17	2.25
	Chuck	15.93	17.89	14.20	1.72
	Rib Eye	6.42	7.59	3.86	1.37
February:	Loin	14.51	17.06	11.53	2.00
	Chuck	18.03	19.68	15.91	1.56
	Rib Eye	7.201	8.76	4.27	1.77
March:	Loin	16.51	22.22	12.80	3.74
	Chuck	19.51	24.54	15.04	3.16
	Rib Eye	8.22	9.17	4.63	1.76
All month:	Loin	16.50	24.99	10.17	3.25
	Chuck	20.28	29.37	14.20	2.83
	Rib Eye	8.913	13.96	3.86	1.88

Table 3. Optimal Quantities of Each Beef Type Using the Utility Maximization Model, January 1999-March 1999.

Pratt-Arrow Coefficient	Loin	Chuck (metric tons)	Rib eye	Profit (100 million yen)
January:				
-0.000002	6.00	10.01	3.00	1.452
-0.000001	6.00	10.01	3.00	1.452
0.000001	4.00	11.53	5.00	1.477
0.000003	4.00	11.53	5.00	1.477
0.000016	4.00	11.53	5.00	1.477
February:				
-0.000002	6.50	13.51	4.16	1.784
-0.000001	6.50	13.45	4.21	1.784
0.000001	4.22	16.00	6.00	1.806
0.000003	4.22	16.00	6.00	1.806
0.000016	4.41	15.62	6.00	1.805
March:				
-0.000002	8.00	11.64	5.39	1.924
-0.000001	8.00	13.37	3.87	1.918
0.000001	4.50	16.53	7.00	1.961
0.000003	4.50	16.53	7.00	1.961
0.000016	4.50	16.53	7.00	1.961

Figure 1. Estimated Profits for Each Attitude-Toward-Risk Segment

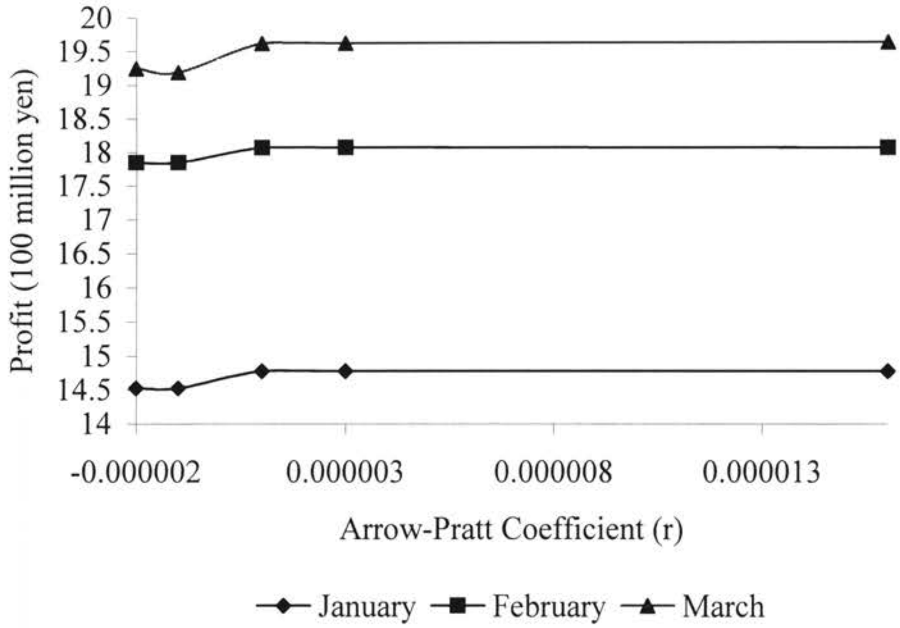
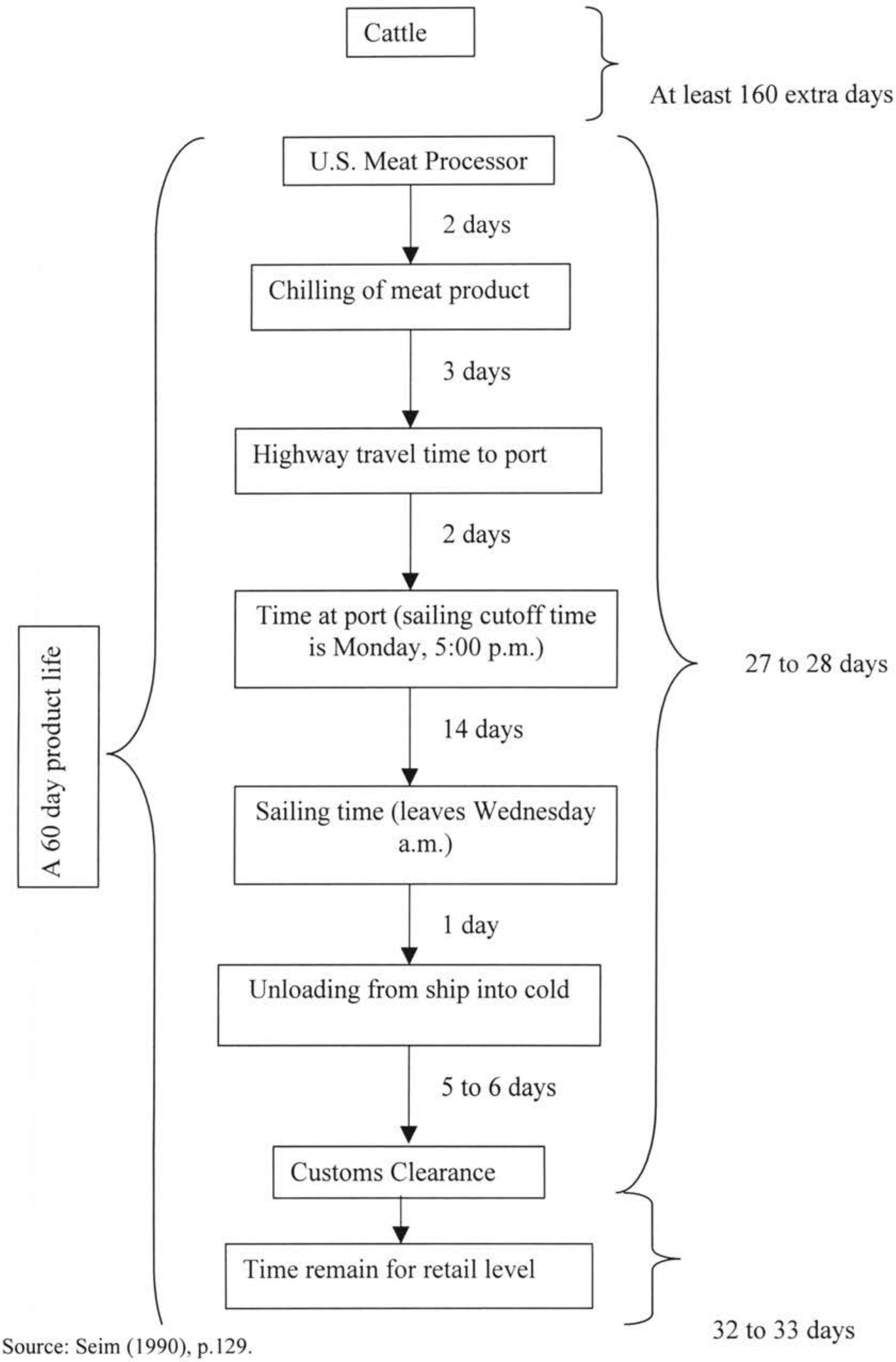


Figure 2. Logistics of U.S. Beef Chilled to Japan



Source: Seim (1990), p.129.

Chapter II

Feasibility of Growing Alternative Crops in Oklahoma

ABSTRACT

In order to convince farmers to switch from growing their traditional crops to a new one, one needs to estimate the profits from the new crop as well as the risks associated with growing it. The Oklahoman farmers have been encouraged to grow alternative high profit crops to enhance their income. It is possible that the higher income generated from one crop may be associated with higher uncertainty than the other lower income crop. Thus, if a farmer is risk averse he/she may be more satisfied by growing a less profitable but less risky crop. Consequently, in this study, a simulation approach is used to incorporate risk into the projected income distribution for the selected crops. Then, the expected net incomes, resulting from the simulation, are ranked by stochastic dominance with respect to a function. The results showed risk seeking farmer would have preferred tomatoes while risk averse farmer would have preferred cucumber. The results of stochastic dominance with respect to a function showed that extremely-risk-averse and risk-averse farmers are likely to prefer cucumbers to other crops while risk-neutral and risk-seeking farmers are likely to prefer tomatoes. In addition, slightly-risk-neutral farmers are likely to prefer cucumbers, snap beans, and tomatoes. The method introduced in this study is a good tool for farmers to select crops that fit their risk attitude.

Introduction

Many farmers in Oklahoma are looking for new enterprises to supplement farm incomes. Low market prices for traditional crops have led many agricultural producers to consider alternative crops as potential sources of incomes (Lloyd, Nelson, Schatzer, Tilley, and Jobes). With this in mind, Oklahoma Extension Service, has introduced several alternative crops, which can be successfully grown in Oklahoma. However, before producers decide to grow an alternative crop they should carefully evaluate its profit potential. Tomatoes have been identified as a crop that shows promise of higher profits. In fact, research shows that some alternative crop such as tomatoes can provide a net return as high as $5000 per are. This is much greater than the net return of $100 for traditional crops like soybeans and wheat. Additionally, some other crops (such as bell peppers, cucumbers, sweet potatoes, sweet corns, and snap beans), that also give a higher profit per acre than traditional crops, should be considered as well. In addition to looking at the profitability of alternative crops, on should bear in mind that each crop has a different risk of output yield and market price associated with it. The level of risk associated with each crop can be estimated from the probability (or estimated probabilities) of potential outcomes. Each producer should choose a crop based on his/her own financial situation and willingness to take risk. This implies that, to make informed decisions, farmers need to have information about expected yield and expected price of the crop.

Before convincing conclusions can be drawn about farming alternative crops in Oklahoma, at least the following three questions need to be answered: (1) How does variations in weather affect the yield of those alternative crops? (2) What is the expected income of the alternative crop over time? (3) How does expected income from one alternative crop compare with other crops? Answering these questions is important because farmers are not likely to switch from growing traditional crop to alternative crops unless they are more profitable and they suit farmers' risk tolerance level.

Objective

The general objective of this study is to obtain the feasibility of growing alternative crops in Oklahoma. To achieve this objective, we need to take the following two steps:

1. To estimate the profitability of growing alternative crops.
2. To estimate income variability, and hence the risk, of growing alternative crops that Oklahoma farmers can grow.

Literature Review

The profitability of growing any crop is based on two random variables, price and yield (O'Donnell and Woodland, 1995). Therefore, any model predicting profitability must incorporate the probability information describing the distribution of random events affecting returns to alternative decisions (Preckel and DeVuyst, 1992). As stated by Petr (1991), the fluctuation of crop yield from year to year is mainly due to variations in weather conditions (p. 12). Several past studies have used crop response models to estimate the effect of weather variables on corn yield [Thompson (1969), Gallagher (1986), Offutt, Garcia, and Pinar (1987), and Dixon, Hollinger, Garcia and Tirupattur (1994)]. The common variables used in these studies are temperature, and precipitation.

Lutgen and Helmers (1979), Bailey and Richardson (1985), and Schilizzi and King (1999) have used a simulation model to generate the income distribution from crops given the variability in price and yield. The common factor between these studies is the use of historical price data to estimate price uncertainty. Recently, Schilizzi and King also used the Model of an Uncertain Dry land Agricultural System (MUDAS) to integrate climatic, agronomic, and economic information to investigate the impact of price and yield uncertainty on the value of new legumes.

The current study also uses a simulation model to estimate the income uncertainty due to price and yield variability. Unlike the Bailey and Richardson and Shilizzi and King studies, the expected income of each crop is examined instead of a whole farm. Similar to Bailey and Richardson, stochastic dominance is used to rank the expected income. The advantages of using the simulation model to estimate the income distribution are as follows: First, the simulation model easily and directly incorporates stochastic information and it has less limiting model assumptions (Anderson, 1974). Second, the model does not assume a normal distribution for the random variables because several studies have shown that random variables such as return and yield are not normally distributed [Day (1965), and Taylor (1990)].

Conceptual Framework

Stochastic dominance with respect to a function was used to order risky choices for decision makers whose absolute risk aversion functions lie within a specified interval. The advantage of this criterion is that it imposes no preset boundary on the risk aversion interval of risk attitude. Let y be a performance criterion (i.e. profit) and u (y), u′(y), u''(y), and - u''(y)/u'(y) be utility of y, its first derivative, its second derivative and Pratt Arrow risk aversion level. Given the two cumulative distributions $F(y)$ and $G(y)$, and the lower and upper bound $r_1(y)$, and $r_2(y)$, the process identifies a utility function $u_0(y)$ which minimizes

$$(1)\ \int_{-\infty}^{\infty}[G(y)-F(y)]u'(y)dy,$$

subject to

$$(2)\, r_1(y) \leq \frac{-u''(y)}{u'(y)} \leq r_2(y),$$

for all y (King and Robinson). For a given class of decision-makers, if the minimum value from equation (1) is positive then $F(y)$ is preferred to $G(y)$. If the minimum value of equation (1) is zero, the decision-maker may be indifferent between the two alternatives. Thus, the distributions can not be ranked. If the minimum number is negative, $F(y)$ is not precisely preferred to $G(y)$. In this case, equation (1) should be flipped over to $\int_{-\infty}^{\infty}[F(y)-G(y)]u'dy$, and then, minimized subject to equation (2). If the minimum number from the converted equation is still negative, neither distribution is definitely preferred to the other.

Model

The simulation model estimated the profitability of alternative crops. The estimation procedure was divided into 4 steps. First, historical yield was estimated as a function of weather variables (equation 3), using linear programming to minize the sum of squares error[2].

$$(3)\ y_{j,} = \alpha_{0j} + \beta_{ij} rain_{ij} + \delta_{ij} temp_{ij} + \varepsilon_j$$

where y_j is yield of j^{th} crop, $rain_{ij}$ is mean precipitation of month i^{th}, $temp_i$ is mean temperature of month i, α_{0j} is the intercept term, β_{ij}, is parameter estimates of mean precipitation at month i^{th} and δ_{ij} is parameter estimates of mean temperature at month i^{th} and ε_j is the j^{th} error term.

Second, the empirical distribution of weather variables was constructed based on actual historical data. Then, a series of 100 expected yields were calculated from the product of randomly drawn weather variables and their parameters estimates. Third, a series of 100 expected revenue data points were created using the 100 expected yields (from the second step) and prices (randomly drawn from their empirical distribution). Finally, expected net incomes (the expected revenue less cost) were evaluated by stochastic dominance with respect to a function.

Data

In this study, the 1895 to 1999 monthly average precipitation and temperature were used because this is the largest range of data available from the National Climate Data Center. Costs of growing crops were obtained from 1997 Oklahoma State University enterprise budget. The seasonal prices of alternative crops from 1970 to 1997 were obtained from

[2] Because a limited amount of crop yield data (for the crops used in this study) were available, the numbers of weather variables exceeded the number of observed yields. Because adding more observations to the data series is not possible, the parameters estimates are calculated using linear programming to minimize sum of square error with the assumption of mean zero and variance of one for the disturbance term. These parameters estimates are used as a proxy in this study.

the USDA *Wholesale Market Prices at Dallas*. The annual yields of alternative crops from 1983 to 1999 were gathered from *The Vegetable Trial Report*.

The nominal prices and costs, which included the inflation effect, are not appropriate for this model because it would treat each individual point in the historical series equally and would account for inflation. Without deflating, the variance of income would be too high. Therefore, using 1996 as the base year, nominal prices and costs were deflated by the GDP deflator obtained from International Finance Statistic yearbook.

Results

Statistics Summary

The mean, variance, maximum and minimum of simulated expected income of each crop are shown in Table 1. The various crops, ranked in descending order, in terms of mean expected income are as follows: tomatoes, cucumbers, snap beans, bell peppers, sweet potatoes, and sweet corn. The various crops, ranked in descending order, in terms of their income variance are: tomatoes, snap beans, cucumbers, bell peppers, sweet potatoes, and sweet corns. Thus, the three highest ranked crops in terms of their expected incomes and income variances are tomatoes, cucumbers and snap beans respectively. Note, the expected income and the income variances of the crops are independent variables in that it is possible for a crop to have a high expected income as well as a high income variance or to have a high expected income and a low income variance.

Cumulative Distribution Function

Figure 1 shows the cumulative distribution function (CDF) of expected income. At a given income level, a crop that has a smaller CDF has lower chance of having a smaller profit as compared to a crop that has a larger CDF. Conversely, at a given income level, a crop that has a higher CDF has a higher chance of having a lower profit.

Stochastic Dominance with Respect to a Function Results

Table 2 shows the ranks of crops on expected income level when we use stochastic dominance with respect to a function. It indicates that decision-makers whose risk attitude is between 0.0003 to 0.0015 (extremely risk averse) and 0.0001 to 0.0003 (risk averse) are likely to prefer cucumbers to other crops. As discussed previously, cucumbers have the least income variance among the three crops that have the highest mean expected income. It is likely that its expected profits are high enough for risk averse and slightly risk averse farmers to overlook the fact that its variation in expected income is higher than traditional crops. Although sage and onions could produce higher profit, they are too risky for risk averse farmers. Slightly risk neutral decision-makers (whose risk attitude is between –0.00005 to 0.0001) are likely to prefer cucumbers, snap beans and tomatoes to other crops. Risk neutral farmers (whose risk attitude is zero) will prefer tomatoes to other crops. This is because risk neutrals favor the highest expected value without considering variance. Risk seeking farmers (whose risk attitude is between –0.0002 to –0.00005) are likely to prefer tomatoes to other crop. As expected, while tomatoes is likely to produce the highest expected income, it is also the riskiest in terms of its income variance. The result agree with the theory of risk preference behavior.

Conclusions

In recent years, Oklahoma State University Agriculture Extension Service has introduced Oklahoma farmers to several non-traditional crops that are likely to provide them with higher incomes. However, before farmers adopt these crops they are likely to require answers to at least three key questions: (1) How do variations in weather affect the yields of these crops? (2) What is the expected income of these crops over time? (3) How does the expected income from these crops compare with other crops grown in Oklahoma? Answering these questions is important because farmers are unlikely to switch crops unless it is more profitable for them and it suits their level of risk tolerance. Incorporating risk into the expected profit projections is important because crops that provide higher than normal income may also be associated with higher than normal risk. In addition, because the risk attitude is likely to differ across farmers, the "best" crop for a farmer will depend on the risk/reward tradeoff he/she wants to make. The results of stochastic dominance with respect to a function showed that extremely-risk-averse and risk-averse farmers would have preferred cucumbers to other crops while risk neutral and risk seeking farmers would have preferred tomatoes. Slightly-risk-neutral farmers would have preferred cucumbers, snap beans, and tomatoes. The simulation method used in this study will provide farmers with information about the risk/reward tradeoffs involved in growing these new crops.

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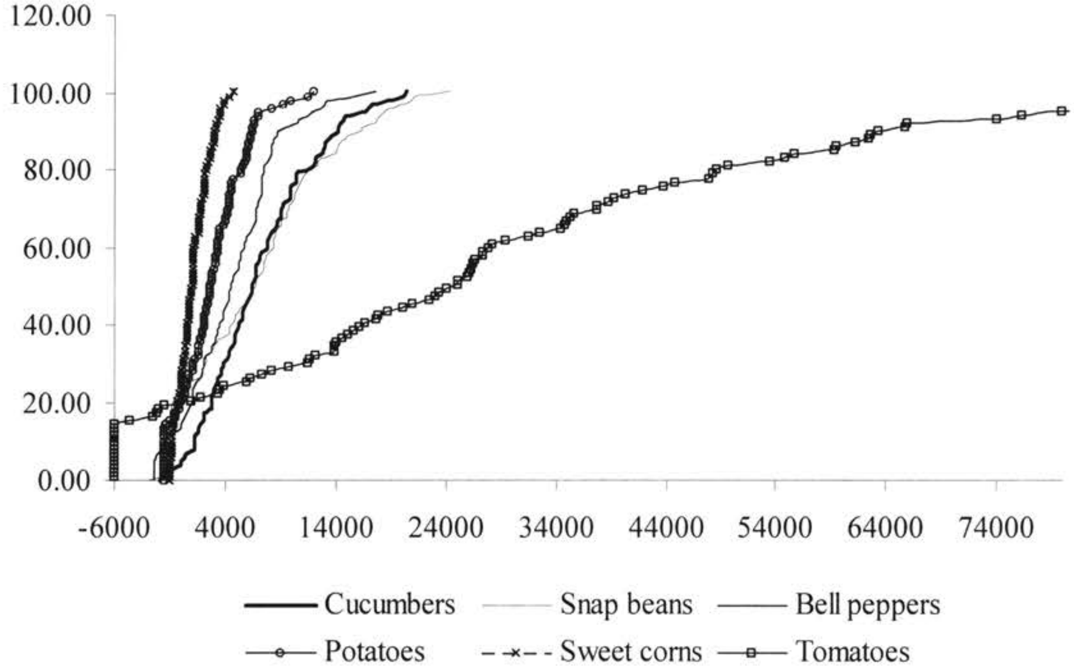
Table 1. Mean, Standard Deviation, Maximum and Minimum and Skewness Value of Expected Income Generated by Simulation method.

Crop	Mean	Standard Deviation	Highest	Lowest	Skewness
Cucumber	6815	5007	20482	-1867	0.6
Snap beans	6749	6484	24399	-3556	0.52
Bell pepper	4519	4214	17696	-2344	0.41
Tomatoes	27282	29373	122299	-5914	0.88
Sweet potatoes	2756	3043	11998	-1555	0.53
Sweet corn	1084	1399	4665	-963	0.41

Table 2. The Results Using Stochastic Dominance with Respect to a Function to Discriminate between Preferred and Non-preferred According to Risk Attitude of Decision Makers.

Crop	Not Preferred crops				
	Risk attitude and Arrow-Pratt Interval				
	Extremely Risk averse .0003 to .0015	Risk averse .0001 to .0003	Risk neutral 0 to 0	Slightly risk neutral -0.00005 to 0.0001	Risk preferring -0.0002 to –0.00005
Bell Peppers	Tomatoes	Sweet corns, Sweet potatoes, and Tomatoes	Sweet potatoes, and Sweet corns	Sweet potatoes, and Sweet corns	
Cucumber	Bell peppers, Snap beans, Sweet corns, Sweet potatoes, and Tomatoes	Bell peppers, Snap beans, Sweet corns, Sweet potatoes, and Tomatoes	Snap beans, Bell peppers, Sweet potatoes, and Sweet corns	Bell peppers, Sweet potatoes, and Sweet corns	Bell peppers, Sweet corns, Sweet potatoes
Snap beans	Tomatoes	Bell peppers, Sweet corns, Sweet potatoes, and Tomatoes	Bell peppers, Sweet potatoes, and Sweet corns	Bell peppers, Sweet potatoes, and Sweet corns	Bell peppers, Cucumbers, Sweet corns, Sweet potatoes
Sweet corns	Tomatoes				
Sweet potatoes	Tomatoes	Tomatoes, and Sweet corns	Sweet corns	Sweet corns	Sweet corns
Tomatoes	Tomatoes		Cucumbers, Snap beans, Sweet corns, Sweet potatoes, and Tomatoes	Sweet corns	Bell peppers, Cucumbers, Snap beans, Sweet corns, Sweet potatoes,
Efficient set	Cucumbers	Cucumbers	Tomatoes	Cucumbers, Snap beans, and Tomatoes	Tomatoes

Figure 1. Cumulative Distribution Function of Expected Income Generated by Alternative Crops.



Chapter III

Selecting the Appropriate Functional Form: The Monte Carlo Nonnested Hypothesis Testing Approach

ABSTRACT

The two popular demand systems, the Rotterdam model and the Almost Ideal Demand System, are always used to estimate demand for agricultural products. However, the sizes of the elasticity estimates may vary from model to model. Hence, doing hypothesis testing involving parameter estimates might give different conclusions when different models are used. Two approaches that have been suggested as a way to select among functional forms are testing theoretical restrictions and Monte Carlo hypothesis tests. In this study, Monte Carlo experiments were conducted to investigate the performance of the two alternative ways of selecting among models.

The results suggest that the use of an incorrect functional form did not lead to higher (as compared to the true model) probability of rejecting the demand restriction (homogeneity and symmetry) and weak separability hypotheses. Thus, this study indicates that, failing to reject the demand restriction and weak separability hypotheses does not imply that the appropriate functional form was used. Additionally, this study used the Monte Carlo approach for selecting (between the Rotterdam and AIDS models) the appropriate functional form for estimating demand for meat in Japan. The results indicate that the Rotterdam model is more appropriate than AIDS for estimating demand for meat in Japan.

Introduction

The Almost Ideal Demand System (AIDS) and the Rotterdam model have been the most widely used models for demand estimation. They are popular because they are relatively easy to use and interpret and they allow a comprehensive test of the consumer theory. The two models are similar on several dimensions. For instance, both are second-order locally flexible functional forms. Also, their data requirements are similar in that they need an equal number of parameters and assume linearity in parameters. While both models have been extensively used for demand estimation, there is no economic theory for determining which model is more appropriate for estimating demand in a given situation. Typical goodness of fit measures cannot be used to compare between the models because they use different dependent variables. Ordinarily, the choice between the two is based on the researchers judgement and research priorities (Alston and Chalfant, 1993). Also, the choice between the two models is usually based on whether the parameter estimates and elasticities resulting from estimation of these two model violate the law of demand or do not meet prior expectations (Alston and Chalfant, 1993).

The law of demand can be tested based on several assumptions that follow. The first assumption is the demand restriction proposition, which consists of five sub-propositions. The first proposition is called adding up. This proposition is used to ensure that consumers do not spend more than their income. The second proposition is the nonnegative estimated budget shares or monotonicity; it is based on the assumption that individuals always prefer more to less. The third proposition is homogeneity. This proposition implies that consumers do not have money illusion. For example, if both income and prices were doubled, consumption would not change. The fourth proposition is symmetry, which states that the pure substitution effects between goods are symmetric. The final proposition is the negative semi-definiteness of the substitution effects. That is, all compensated own-price effects must be negative. Note, that satisfying of homogeneity does not necessarily imply the satisfaction of symmetry. The reason being that the symmetry restriction reflects the consistency of consumer's choice while the homogeneity reflects the budget constraint. Implications of the propositions of symmetry and negativity are that falsification of symmetry leads to inconsistent choices and falsification of negativity leads to non-maximization of utility or non-minimization of costs (Cozzarin and Gilmour, 1998).

Another assumption that is widely used in demand analysis is the assumption of weak separability. Researchers have often assumed weak separability to estimate the two-stage (conditional) demand system. The two-stage demand system allows researchers to focus on demand for one commodity and its subcategories (Moschini, Moro, and Green, 1994). However, Pudney tested the assumption of weak separability used in these empirical studies and found that the assumption of weak separability was mostly rejected. Therefore, when modeling conditional demand, a test should be performed to see if weak separability holds.

As results may vary across situations based on the model used, the test of law of demand may be inconclusive for choosing between models. For instance, Alston and Chalfant (1991) found that the Rotterdam model did not reject the null hypothesis of stable preferences while estimation of the AIDS model led to parameter instability. Likewise, Piggot's (1991) results also varied between the Rotterdam model and AIDS: he found a greater effect of advertising variables in the AIDS than the Rotterdam model.

Cozzarin and Gilmour caution that disconfirmation of consumer theory might result due to the use of incorrect functional form. As discussed earlier, Alston and Chalfant (1993) found that the sizes of the parameter estimates might vary across models. Because the way to test the demand proposition and weak separability assumptions is via restricting the parameter estimates, the results of testing hypotheses might lead to different conclusions depending on the model used. For example, existing studies [e.g., Capps, Tsai, Kirby, and Williams, 1994, Hayes, Wahl and Williams, 1990; and Wahl, Hayes and Williams, 1991] used both Rotterdam and AIDS models to estimate Japanese meat demand. In addition, the parameter estimates from these two models were used to test the assumption of weak separability and demand restriction (homogeneity and symmetry). The results of their hypothesis testing failed to reject the assumption of weak separability and demand restriction when both Rotterdam and AIDS models were estimated. However, it is possible that either both models are appropriate for estimating Japanese demand for meat or only one of them is appropriate. Also, no further research has been done in order to select the right functional form for Japanese meat demand.

Another way of selecting the appropriate functional form is by using the Cox principle. Doran (1993) defined the Cox principle as "a method of validating a model (H_0) by comparing the actual performance of another model (H_1) with the prediction, based on H_0, of this performance." (p. 98). This principle can be applied to the log-likelihood ratio test. Assuming, L_0 and L_1 (the maximum log-likelihood values) are obtained from estimating the model under H_0 and H_1, respectively, and L_{01} (the log-likelihood ratio) is calculated as L_0 - L_1. The Cox test value, $T_0 = L_{01} - E\ [L_{01}]$, can be used to evaluate the validity of the model by finding the significance of T_0, where $E\ [L_{01}]$

is the expectation of L_{01} under H_0. As can be expected, T_0 will be close to zero if the difference between L_{01} and E [L_{01}] is very small. This shows the closeness of the log-likelihood ratio to what would be expected when H_0 is true. Conversely, a big difference between L_{01} and E [L_{01}] indicates the difference between the actual and expected value (under H_0) of the log-likelihood ratio. Therefore, the question should be: Is the model under H_0 appropriate?

Because the Rotterdam and AIDS models give different parameter estimates, at least two related questions arise: First, if the common tests of hypotheses applied are valid, does that imply that the correct functional form was used to estimate demand? Second, what is the preferred functional form for analyzing demand for meat in Japan? In this study, the Monte Carlo approach was used as a tool to answer these questions. Note that Capps et al. and Wahl, Hayes and Williams defined meat categories differently in their study. To be consistent with both studies, we used meat categories from both studies.

Objective

The main objectives of this study were: (1) to determine if the validity of demand restrictions (weak separability and demand restrictions) imply the correct functional form used; and (2) to select an appropriate functional form for Japanese demand for meat.

Literature Review

Several procedures have been proposed for selecting a model for demand specification. For instance, Green, Hassan, and Johnson (1995) proposed using the likelihood dominance criterion as a method of model selection. This technique specifies the criteria for choosing between a model with a smaller number of variables or a model with a larger number of variables based on the likelihood ratio. Suppose that, a model under null hypothesis H_1 (with n_1 number of parameters and L_1 the maximum log-likelihood value) is nested within another model under H_2 (with n_2 number of parameters and L_2 the maximum log-likelihood value). Based on the likelihood dominance criterion, the model with the smaller number of unknown parameters is preferred if $L_2 - L_1 < (C(n_2+1) - C(n_1+1))/2$, where $C(n)$ is a chi-squared critical value at degree of freedom n. On the other hand, the model with the larger number of unknown parameter is preferred if $L_2 - L_1 > (C(n_2 - n_1 + 1) - C(1))/2$. In the case that the two models have the same number of parameters, the log-likelihood dominance criterion chooses the model with the higher log-likelihood value. Despite the simplicity of the test, there is no control over type I error.

Recently, Kastens and Brester (1996), used out-of-sample forecasting as a basis for model selection between the absolute price Rotterdam model, a first-differenced linear approximate almost ideal demand system, and a first-differenced double-log demand system. A model is considered good or bad dependent on the ability of the model to predict future demand. Their study used data spanning seventy years (1923 – 1992). Data from the first twenty-five years (1923 - 1948) were used to estimate the models and then the accuracy of forecasting of these models was tested on the remaining forty-three years of data (1949-1992). The model that most accurately predicted the data for the forty-four year sample was preferred. However, such long series of data are rarely available and out-of-sample tests can be highly influenced by structural change.

In 1993, Alston and Chalfant used a compound model and a least squares test to select a model (between AIDS and Rotterdam model) that was appropriate for U.S. meat demand data. Using this technique, they chose the Rotterdam model. Lafrance showed that the technique used by Alston and Chalfant ignored the presence of endogenous variables, and, hence, their results are biased. In addition, he suggested some corrections to improve Alston and Chalfant's technique. However, the power of the test Lafrance's test is too low to distinguish between the two models.

Another nonnested test has been proposed by Coulibaly and Brorsen (1999), a Monte Carlo approach to testing nonnested hypothesis (also known as a parametric bootstrap). Their test procedure is a Cox-type test that is based on the log-likelihood ratio. The idea of the test is to compare the actual test statistic, to the distribution of the test statistics that was generated by Monte Carlo methods. The model under the null hypothesis is to be rejected if the actual value of the test statistic is less than its corresponding simulated value a small number of times. While Coulibaly and Brorsen's general approach is used, the approach has never been developed for demand systems.

Model

The absolute price version of the Rotterdam Model (Theil, 1980) is written as follows:

(1) $$w_i d\ln(q_i) = \Theta_i d\ln(Q) + \sum_{j=1}^{n} \pi_{ij} d\ln(p_j) + e_i \text{ (Rotterdam)}$$

where $d\ln(Q) = \sum_i w_i d\ln(q_i)$ is the Divisia volume index (Capps et. al), w_i is the expenditure share of meat item i at time t, q_i is per capita consumption of meat item i at time t, and p_j is real price of meat item j at time t, e_i, are error terms, Θ_i are the expenditure parameter estimates, and π_{ij} are the prices parameter estimates. The subscript

i and j represent beef, pork, chicken, and marine (fish) products in the model presented by Capps et al. Similarly, the subscript i and j represent import-quality beef, Wagyu beef, pork, chicken, and marine products in the model presented by Hayes, Wahl and Williams. The AIDS (Deaton and Muellbauer, 1980) is

$$(2) \qquad w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X}{P}\right) + u_i \text{ (AIDS)}$$

where $\ln P = \sum_{i=1}^{n} w_i \ln P_i$ is the Stone's index (Hayes, Wahl and Williams), X is the per capita expenditures on all meats in the model, u_i are error terms, α_i are the intercept terms, γ_i are the prices parameter estimates and β_i are the expenditure parameter estimates.

For AIDS, the explanatory variables, natural logarithm of prices ($\ln p_i$) and natural logarithm of total meat expenditure (deflated by Stone's price index), are used to explain the budget share of each meat commodity (w_i). Meanwhile the first-difference of natural logarithm ($d\ln p_i$) and the Divisia volume index ($d\ln(Q) = \sum_i w_i d\ln(q_i)$) are used to explain the product of budget share and the first-difference of natural logarithm of quantity in Rotterdam. Therefore, it would be reasonable to check if the difference in parameter estimates would yield different conclusions with hypothesis testing. The hypothesis testing in this study will examine the assumptions of homogeneity, symmetry, and weak separability. These assumptions are usually required for testing the validity of a demand system.

Restrictions for Testing Consumer Theory

The consumer theory can be tested by the following restrictions:

	Rotterdam model	AIDS
adding up	$\sum_j \Theta_j = 1$;	$\sum_i \alpha_i = 1$,
		$\sum_i \gamma_i = 0$,
		$\sum_i \beta_i = 0$;
homogeneity	$\sum_j \pi_{ij} = 0$;	$\sum_j \gamma_{ij} = 0$;
symmetry	$\pi_{ij} = \pi_{ji}$;	$\gamma_{ij} = \gamma_{ji}$;

Homogeneity and symmetry are only two restrictions that will be examined because adding up is implied by the models used in this study. The generated data sets are checked to determine the relative percentage of reject/non-reject conclusions for the restrictions when the wrong model is specified.

Separability

As suggested by Moschini, Moro, and Green (1994), the weak separability of the direct utility function is the approach used in this study. While this approach is also used by Capps et al., Hayes, Wahl and Williams used quasi-separability. Moschini, Moro, and Green state that quasi-separability is consistent with their approach only if the subutility groups are homothetic. Therefore, it cannot be used to verify second-stage demand systems.

For all $(i, j) \in I_g$ and $(m, k) \in I_s$, for all $g \neq s$, the following restriction for testing weak separability can be maintained in any demand system used here:

(3) $$\frac{\sigma_{ik}}{\sigma_{jm}} = \frac{\eta_i \eta_k}{\eta_j \eta_m}$$

where, $\sigma_{ij} = E_{ij}/w_j$, $E_{ij} = (\partial h_i/\partial p_j)(p_j/q_i)$ is compensated cross-price elasticity, $w_j = p_j q_j/x$ is the budget share on good j, and $\eta_i = (\partial q_i/\partial y)(y/q_i)$. The separability conditions equation

(3) can be tested through the parameters estimated of a demand system. Hence, for AIDS the separability restrictions can be written as[3]

$$(4) \qquad \frac{\gamma_{ik} + \alpha_i \alpha_k}{\gamma_{jm} + \alpha_j \alpha_m} \frac{(\alpha_i + \beta_i)(\alpha_k + \beta_k)}{(\alpha_j + \beta_j)(\alpha_m + \beta_m)} .$$

As for the Rotterdam model, the separability restriction of equation (3) can be expressed as

$$(5) \qquad \frac{\pi_{ik}}{\pi_{jm}} = \frac{\theta_i \theta_k}{\theta_j \theta_m} .$$

Assume that, i is the fish group and (m, k) are meat commodities, such as beef (import quality and domestic), pork, and chicken in other meats group. The weakly separability between fish and other meats restriction can be tested by the modification of equation (4) and (5)

$$(6) \qquad \frac{\gamma_{ik} + \alpha_i \alpha_k}{\gamma_{im} + \alpha_i \alpha_m} \frac{(\alpha_k + \beta_k)}{(\alpha_m + \beta_m)}$$

$$(7) \qquad \frac{\pi_{ik}}{\pi_{im}} = \frac{\theta_k}{\theta_m}$$

respectively.

Testing the Assumptions of the Model

The first part of the study employed the Monte Carlo approach to examine how the use of incorrect demand models might lead to incorrect conclusions from a diagnostic test. Alston and Chalfant (1991) also used the Monte Carlo experiment to examine if the stability assumption was rejected because the wrong functional form was used. In this

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[3] To use the restriction in equation (4), the prices and income are scaled to equal one at the mean. So, the separability restriction for nonlinear AIDS and linear AIDS are identical (Moschini, Moro, and Green, 1994).

study, we used Alston and Chalfant' approach to examine the rejection of the separability and demand restrictions due to use of incorrect functional form. This approach is as follows: The first step is to estimate the model under the null hypothesis. If the null hypothesis is that the Rotterdam is the true model then equation (1) (shown above) is estimated with the imposed restrictions[4]. Generally, one equation needs to be dropped when the Rotterdam model and AIDS are estimated to avoid singularity of the error terms. Here, we generated the error term of the dropped equation using $\sum_{i=1}^{n} e_i = 0$ as suggested by Alston and Chalfant (1991). This methodology is equivalent to finding the dropped equation parameters through the adding up condition. Note that the error terms (e_i) are independent across time but contemporaneously correlated.

The second step was to create 1,000 new data sets from the estimated model. The new data sets were generated stochastically by appending the product of parameter estimates and explanatory variables to the product of the random vectors N (0,1) and the Cholesky decomposition of the covariance matrix. For example, the new sets of predicted left hand side variables of the Rotterdam model, pred$w_i d\ln(q_i)$, can be generated as $predw_i d\ln(q_i) = \hat{\Theta}_i d\ln(Q) + \sum_{j=1}^{n} \hat{\pi}_{ij} d\ln(p_j) + \hat{\sigma}_{rott,i} e_i$, where $\hat{\Theta}_i$ and $\hat{\pi}_{ij}$, are the estimate of Θ_i, and π_{ij}, respectively, and $\hat{\sigma}_{rott,i} e_i$ are product of N (0,1) random vectors and the Cholesky decomposition value.

The third step was to fit the true model (the Rotterdam model) and the alternative

[4] For example, when the demand restrictions are examined, the homogeneity and symmetry restrictions are imposed. On the other hand, if the weak separability assumption is examined, the weak separability restrictions, equation (6) (for AIDS) and equation (7) (for the Rotterdam model), are imposed.

model (AIDS) using the generated data sets[5]. Then, we tested the demand restriction for each data set. The use of the wrong functional form, which results in incorrect assumptions, will be indicated by the high frequency of rejecting the assumptions when the alternative model is estimated. The above mentioned three-steps can be repeated to test if the null hypothesis (i.e., that AIDS is the true model and that Rotterdam is the alternative model) is correct.

Non-nested Hypothesis testing

The objective of the second part of the study was to select the proper demand model using the Monte Carlo hypothesis testing procedure. This procedure involved conducting the Cox-type test that uses the log-likelihood ratio as the test statistic (Coulibaly and Brorsen, 1999; Lee and Brorsen, 1997). The first step was to obtain the actual log-likelihood ratio (L_{01}). This was done by estimating the model under the null hypothesis (H_0) and the alternative hypothesis (H_1) using real data and then calculating their log-likelihood statistics (L_0 and L_1, respectively). The actual log-likelihood ratio was calculated as L_0 - L_1. The second step involved generating 1,000 data sets from the distribution of the error term of the model under H_0. The data were of generated as explained earlier in the "testing assumptions" section. The third step consisted of calculating the simulated likelihood ratio test. As in the first step, we estimated the model under the null and alternative hypotheses using the generated data sets and then

[5] Note that, we need to transform the predicted left-hand side variables of the true model to the left-hand side variables of the alternative model. Since the Rotterdam models involve nonlinear transformations of quantity on the left-hand side, the transformation cannot be done by solving algebraically. Kastens and Brester (1996) suggested obtaining expected quantities form the Rotterdam model using a second Taylor series expansion of the predicted left-hand side (see Appendix A for details of the calculation). For the AIDS model, a predicted quantity and solved by $q = (predw)(x/p)$, where *predw* is predicted budget share in (2). Note that the equation-specific i and t were dropped except where the lagged variable needed to be indicated.

obtained their simulated log-likelihood statistics. Following this, the simulated likelihood ratio statistic for the j[th] data set was calculated as L_{0j} - L_{1j} where L_{0j} and L_{1j} are the maximized log-likelihood value under H_0 and H_1 respectively. Finally, the significance level of the test or p-value is obtained as $p-value = \frac{numb[L_{0j} - L_{1j} \leq L_{01}]+1}{M+1}$ where numb[L_{0j}-L_{1j}≤L_{01}] is the number of elements of the set for which the specified relationship is true, and M is the number of the data sets that we generated in the second step (1,000 in this case).

Data

Data sources are the same as used by Hayes, Wahl and Williams and Capps et al., but the time period is 1965 – 1996. The expenditure and price data are from various publications by the Japanese Ministry of Agriculture, Forestry, and Fisheries (MAFF). The disappearance for Wagyu beef, import-quality beef, pork, and chicken are calculated as production plus imports. The data for production and import of Wagyu beef, import-quality beef, pork, chicken and fish are obtained from Statistical Yearbook. Prices for pork and chicken meat were obtained from *Meat Statistics in Japan*. The overall fish price is an average of fresh and salted fish prices and weighted by the their disappearance (the fresh and salted fish prices are available in the *Annual Report of the Family Income and Expenditure Survey*). The only available prices for Wagyu and dairy beef are wholesale prices which are published in *Statistics of Meat Marketing and Meat in Japan*. The retail prices of Wagyu and dairy are calculated by multiplying the respective available wholesale prices available by 2.1156 (this coefficient is from Hayes, Wahl and

Williams). Capps et al. meat categories were beef, pork, chicken, and fish while Hayes, Wahl, and Williams meat categories were Wagyu beef, import quality beef, pork, chicken, and fish.

Three sets of data ranges were used in this study: The first set, from 1965 to1986, was used in Hayes, Wahl and Williams. The second set, from1965 to1991, was used in Capps et al. The last set, from 1965 to1996, is the most recently available data that could be obtained for this study. The Monte Carlo experiment was created using PROC IML available in SAS. Using SAS' RANDOM command $N(0,1)$ random vectors were generated. To confirm the validity of the Monte Carlo experiment, we examined whether the parameters estimates from PROC IML agree with the parameter estimates from PROC SYSLIN (also available in SAS).

Results

For comparison purposes, parameter estimates and elasticities for both the Rotterdam model and AIDS using Capps et al. meat categories are shown in Table 1 and 2 respectively. Likewise, the parameter estimates and elasticities for both the Rotterdam model and AIDS using Hayes, Wahl and Williams meat categories are shown in Table 3 and 4. Unsurprisingly, the parameter estimates of both models are not identical. This is because explanatory variables of the Rotterdam and AIDS are different and dependent variables are different (see equation 1 and 2 for the more detail). Unlike parameter estimates, elasticities of the two models should be interpreted in the same way. However, the elasticities from Rotterdam and AIDS, in this study, are not exactly equivalent. Table 2, shows the Marshallian own-price elasticities using Capps et al. meat categories. When AIDS was estimated, own-price elasticities of beef, pork, chicken, and fish were –0.0826,

-0.2337, -0.5108 and .2338 respectively while they were -0.5996, -0.5083, -0.1791 and -0.1503 respectively when the Rotterdam was estimated. Similarly, Table 4 shows the Marshallian own-price elasticities using Hayes, Wahl, and Williams meat categories. When AIDS was estimated, the own-price elasticities of Wagyu beef, import quality beef, pork, chicken, and fish were –1.5977, -0.5493, -0.6475, -0.5090 and -0.0959 respectively while they were –1.5053, -0.1891, -0.5042, -0.2259 and -0.1439 respectively when Rotterdam was estimated.

Demand restriction

Table 5 shows the percent of rejections of the demand restriction hypothesis when the true and alternative models were estimated. The demand restrictions were tested using the Wald and the log-likelihood ratio test. It showed a slight bias toward rejecting the null hypothesis. This bias can be detected from the rejection of the null hypotheses of demand restriction when the true model was estimated using data generated from the true model itself. Using the Wald test, as well as the log likelihood ratio test, the results showed that bias toward rejection is higher when the symmetry restrictions were tested than when the homogeneity restrictions were tested. For example, the results of using Capps et al. meat categories for estimating the models and testing the hypotheses are as follows: for the Wald test, when data generated by the Rotterdam model were used to estimate the Rotterdam model, the percent of rejections of symmetry restrictions were 17.8 at the 5% level and 4.8 at the 1% level. For log likelihood ratio test, the percent of rejections of symmetry restrictions were 39.3 at the 5% level and 14.3 at the 1% level. Correspondingly, there were no rejections of the homogeneity restriction at the 5% level and at the 1% level using both the Wald test and the log likelihood ratio test. A higher percent of rejections of the symmetry restrictions than the rejections of the homogeneity restrictions were also found when the AIDS generated data were used to estimate the AIDS model. Similar to the results when Capps et al. meat categories were used, the results of using Hayes, Wahl and Williams meat categories for estimating the models and testing the hypotheses showed that the percent of rejections of symmetry restrictions were higher than the rejections of the homogeneity restrictions (i.e., when the AIDS generated data were used to estimate the AIDS model and when the Rotterdam generated data were used to estimate the Rotterdam model).

When we fit the alternate model to the data generated by the true model, the results were as follows: When the data generated by the Rotterdam model were used to estimate the Rotterdam model, the rejection of demand restrictions was substantially less as compared to when the data generated by Rotterdam model were used to estimate the AIDS model. The results also showed that when AIDS generated data were used to estimate the Rotterdam model, the probability of rejection was slightly less than when the data generated by AIDS was used to estimate the AIDS model itself. Thus, the Rotterdam model seems to be more robust than the AIDS model.

Weak Separability

The results of weak separability tests are shown in Table 6. Similar to the testing of demand restrictions, there is no clear indication of the false rejection of weak separability hypothesis when the alternative model was used. When we used the data generated by the true model to estimate the alternate model, the percentage of rejections of weak separability restrictions were the same as when we fit the true model to the data generated by the true model using both Capps et al. meat categories and Hayes, Wahl and Williams meat categories.

Functional form

P-values were used as a criterion for rejecting the model under the null hypothesis. As discussed earlier (in the 'Non-nested Hypothesis Testing' section), the p-values were used as a criterion. If the p-value is greater than the 0.05 level then we fail to reject the model under the null hypothesis at the 5% level. On the other hand, the model under the null hypothesis should be rejected if the p-value is less than 0.05. From Table 7, the p-values in all cases indicated that the Rotterdam model was not rejected for Japanese meat demand at the 5% level. On the other hand, AIDS was rejected for Japanese meat demand in all cases at the 5% level. Therefore, the Rotterdam model is preferred. Note, we failed to reject the demand restrictions and weak separability assumptions when the Rotterdam and AIDS models were used to estimate Japanese meat demand. Without the results of non-nested hypothesis testing, we could have selected the wrong functional from and, hence, incorrect elasticities; also, we could have drawn wrong conclusion about Japanese meat demand and constructed inappropriate policies for the Japanese market.

Conclusions

In this study, although the AIDS model was rejected for Japanese meat demand, the demand restrictions (homogeneity and symmetry) and weak separability were not rejected. From the Monte Carlo experiments, we found that although the demand restrictions may hold for a model, this does not necessarily imply that the appropriate functional form was used. This finding has important implications for interpreting the results of existing studies where the authors conducted hypothesis testing without testing for the appropriateness of the functional form used. Specifically, unless tests for appropriateness of functional form used were conducted, finding support for the hypotheses does not necessarily imply that the appropriate functional form was used. Therefore, we recommend that the test of functional form used be conducted at the outset to ensure that the demand model selected is based on theory and the actual environmental conditions under which the data was generated. In conclusion, this study shows the importance of testing the appropriateness of the functional form used and also shows how the Monte Carlo technique can be used to help researchers choose between Rotterdam and AIDS models.

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Table 1. The Parameter Estimates of the Rotterdam ($w_i d\ln(q_i)$) and AIDS (w_i) Models Using Capp et al. Meat Categories, 1965-1996.

Model	Commodity	Expenditure Coefficient	Price Coefficients			
			Beef	Pork	Chicken	Fish
AIDS	Beef	.0633	.0313	.0101	-.0045	-.0370
		(.0216)	(.0100)	(.0086)	(.0070)	(.0122)
	Pork	-.0230	.0101	.0709	-.0531	-.0279
		(.0309)	(.0086)	(.0162)	(.0120)	(.0190)
	Chicken	.0564	-.0045	-.0531	.0656	-.0080
		(.0374)	(.0070)	(.0120)	(.0177)	(.0217)
	Fish	-.0967	-.0370	-.0279	-.0080	.0729
		(.0616)	(.0122)	(.0190)	(.0217)	(.0372)
Rotterdam	Beef	.1574	-.0793	.0732	-.0050	.0011
		(.0741)	(.0226)	(.0202)	(.0104)	(.0237)
	Pork	.2665	.0732	-.1096	-.0031	.0394
		(.0865)	(.0202)	(.0304)	(.0135)	(.0302)
	Chicken	.1707	-.0050	-.0031	-.0215	.0295
		(.0415)	(.0104)	(.0135)	(.0157)	(.0195)
	Fish	.4054	.0110	.0394	.0295	.0800
		(.0960)	(.0237)	(.0302)	(.0195)	(.0461)

Table 2. The Marshallian Elasticities of the Rotterdam and AIDS Models of Japanese Meat Demand, Using Capp et al. Meat Categories, 1965-1996.

Model	Commodity	Expenditure Elasticities	Price Elasticities			
			Beef	Pork	Chicken	Fish
AIDS	Beef	1.4790	-.0826	-.0266	-.0914	-.5347
		(.1634)	(.0656)	(.0713)	(.0418)	(.1764)
	Pork	.8934	-.6479	-.2337	-.0729	.1793
		(.1435)	(.0352)	(.0674)	(.0470)	(.1636)
	Chicken	1.4690	-.0992	-.5431	-.5108	-.3159
		(.3118)	(.0415)	(.1136)	(.1169)	(.3450)
	Fish	.8182	-.0455	-.0133	-.9931	.2338
		(.1158)	(.0158)	(.0311)	(.0301)	(.1313)
Rotterdam	Beef	1.1901	-.5996	.5537	-.0375	.0835
		(.5604)	(.1707)	(.1529)	(.0788)	(.1791)
	Pork	1.2363	.3397	-.5083	-.0142	.1829
		(.4011)	(.0938)	(.1410)	(.1400)	(.1399)
	Chicken	1.4203	-.0412	-.0254	-.1791	.2457
		(.3450)	(.0866)	(.1127)	(.1304)	(.1623)
	Fish	0.7620	.0207	.0741	.0555	-.1503
		(.1804)	(.0445)	(.0567)	(.0367)	(.0867)

Table 3. The Parameter Estimates of the Rotterdam ($w_i d\ln(q_i)$) and AIDS (w_i) Models Using Hayes, Wahl and Williams Meat Categories, 1965-1996.

Model	Commodity	Expenditure Coefficients	Price Coefficients				
			Wagyu	Import Quality Beef	Pork	Chicken	Fish
AIDS	Wagyu	-.0364	-.0424	.0028	.0261	-.0019	.0154
		(.0339)	(.0183)	(.0087)	(.0148)	(.0126)	(.0181)
	Import Quality Beef	.1082	.0028	.0365	-.0004	-.0038	-0350
		(.0212)	(.0087)	(.0059)	(.0079)	(.0072)	(.0107)
	Pork	-.0115	.0261	-.0004	.0735	-.0505	-.0487
		(.0367)	(.0148)	(.0079)	(.0185)	(.0125)	(.0198)
	Chicken	.0622	-.0019	-.0038	-.0505	.0665	-.0103
		(.0406)	(.0126)	(.0072)	(.0125)	(.0183)	(.0219)
	Fish	-.1224	.0154	-.0350	-.0487	-.0103	.0786
		(.0624)	(.0181)	(.0107)	(.0198)	(.0219)	(.0359)
Rotterdam	Wagyu	.0743	-.1007	.0097	.0545	.0113	.0253
		(.0649)	(.0173)	(.0095)	(.0177)	(.0102)	(.0197)
	Import Quality Beef	.0971	.0097	-.0124	.0263	-.0110	-.0127
		(.0415)	(.0095)	(.0010)	(.0118)	(.0082)	(.0158)
	Pork	.2505	.0545	.0263	-.1088	-.0046	.0325
		(.0874)	(.0177)	(.0118)	(.0292)	(.0135)	(.0296)
	Chicken	.1655	.0113	-.0110	-.0046	-.0272	.0315
		(.0441)	(.0102)	(.0082)	(.0135)	(.0164)	(.0200)
	Fish	.4127	.0253	-.0127	.0325	.0315	-.0767
		(.0972)	(.0197)	(.0158)	(.0296)	(.0200)	(.0457)

Table 4. The Marshallian Elasticity of the Rotterdam and AIDS Model, Using Hayes, Wahl and Williams Meat Categories, 1965-1996.

Model	Commodity	Expenditure Elasticities	Price Elasticities				
			Wagyu	Import Quality Beef	Pork	Chicken	Fish
AIDS	Wagyu	.4555	-1.5977	.0770	.5079	.0368	.5204
		(.5074)	(.2878)	(.1131)	(.1868)	(.1488)	(.5241)
	Import Quality Beef	2.6552	-.0683	-.5493	.3636	-.2576	-1.4164
		(.3250)	(.1454)	(.0759)	(.1004)	(.0839)	(.3304)
	Pork	.9465	.1249	.0014	-.6475	-.2277	-.1975
		(.1704)	(.0744)	(.0305)	(.0690)	(.0476)	(.1796)
	Chicken	1.5178	-.0506	-.0657	-.5315	-.5090	-.3610
		(.3375)	(.1129)	(.0484)	(.1074)	(.1187)	(.3576)
	Fish	.7685	-.0508	-.0419	-.9917	.2701	.0959
		(.1174)	(.0362)	(.0163)	(.0297)	(.0302)	(.1288)
Rotterdam	Wagyu	1.1104	-1.5053	.1450	.8142	.1684	.3777
		(.9703)	(.2592)	(.1425)	(.2653)	(.1530)	(.9703)
	Import Quality Beef	1.4861	.1484	-.1891	.4031	-.1682	-.1942
		(.6357)	(.1458)	(.1506)	(.1801)	(.1253)	(.2415)
	Pork	1.1620	.2527	.1222	-.5042	-.0214	.1508
		(.4056)	(.0823)	(.0546)	(.1354)	(.0627)	(.1374)
	Chicken	1.3769	.0937	-.0914	-.0384	-.2259	.2620
		(.3666)	(.0851)	(.0681)	(.1124)	(.1361)	(.1668)
	Fish	.7756	.0475	.0239	.0611	.0592	-.1439
		(.1826)	(.0371)	(.0297)	(.0557)	(.0377)	(.0858)

Table 5. The Percentages of Rejections of Demand Restrictions (Based on 1,000 Replications of Simulated Data).

Model		Demand restriction	Percent of rejections of demand restriction			
			Using Wald test		Using Log-likelihood ratio test	
True	Alternative		$\alpha = 0.05$	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.01$
Capps et al.						
Rotterdam	Rotterdam	Symmetry	17.8	4.8	39.3	14.3
		Homogeneity	0	0	0	0
	AIDS	Symmetry	59.7	33.6	89.1	51.7
		Homogeneity	6.1	1.5	8.3	1.9
AIDS	Rotterdam	Symmetry	5.3	1.3	10.8	3.2
		Homogeneity	0	0	0.1	0
	AIDS	Symmetry	10.6	3.4	14.8	4.1
		Homogeneity	8.4	2.9	10.6	3.3
Hayes, Wahl and Williams						
Rotterdam	Rotterdam	Symmetry	18.8	6.9	19.5	7.3
		Homogeneity	0.5	0	0.9	0.3
	AIDS	Symmetry	69.5	42.2	89.7	72.1
		Homogeneity	10.1	5.8	17.7	6.3
AIDS	Rotterdam	Symmetry	14.4	3.7	10.6	7.1
		Homogeneity	0.1	0	0.9	0.1
	AIDS	Symmetry	13.8	4.6	24.2	8.1
		Homogeneity	9.3	5.2	13.8	5.4

Table 6. The Percentages of Rejections of Weak Separability Restrictions (Based on 1,000 Replications of Simulated Data).

Model		Percent of rejections of weak separability restrictions	
True	Alternative	$\alpha = 0.05$	$\alpha = 0.01$
Capp et al.			
Rotterdam	Rotterdam	4.0	2.4
	AIDS	2.4	4.0
AIDS	Rotterdam	6.0	0
	AIDS	4.8	8.0
Hayes, Wahl, and Willams			
Rotterdam	Rotterdam	7.2	8.0
	AIDS	4.8	2.7
AIDS	Rotterdam	1.6	4.0
	AIDS	16.0	8.0

Table 7. The P-value Resulting from Using the Monte Carlo Hypothesis Testing to Select the Demand Model.

Data Period	True model	p-value
1965-1986	Capps et al.:	
	H_0: Rotterdam	0.628
	H_0: AIDS	0.001
	Hayes, Wahl and Williams:	
	H_0: Rotterdam	0.732
	H_0: AIDS	0.001
1965-1991	Capps et al.:	
	H_0: Rotterdam	0.706
	H_0: AIDS	0.001
	Hayes, Wahl and Williams:	
	H_0: Rotterdam	0.771
	H_0: AIDS	0.001
1965-1996	Capps et al.:	
	H_0: Rotterdam	0.796
	H_0: AIDS	0.001
	Hayes, Wahl and Williams:	
	H_0: Rotterdam	0.845
	H_0: AIDS	0.001

Appendix A

The Rotterdam model is written as:

$$\hat{w}_{i,t}\Delta\ln Q_{i,t} = \alpha_i + \sum_{j=1}^{n}\gamma_{ij}\Delta\ln p_{j,t} + \beta_i[\Delta\ln x_t - \sum_{j=1}^{n}\hat{w}_{j,t-1}\Delta\ln p_{j,t}] + \varepsilon_t$$

Let the predicted LHS equal to z + ε:

$$\hat{w}\Delta\ln Q = z + \varepsilon$$

$(½)[w + w_{(-1)}][\ln Q - \ln Q_{(-1)}] = z + \varepsilon$

$[w + w_{(-1)}][\ln Q - \ln Q_{(-1)}] = 2\ z + 2\ \varepsilon$

$[(pQ/x) + w_{(-1)}][\ln Q - \ln Q_{(-1)}] = 2\ z + 2\ \varepsilon$

$[pQ + xw_{(-1)}][\ln Q - \ln Q_{(-1)}] = 2x\ z + 2x\ \varepsilon$

$pQ\ln Q + xw_{(-1)}\ln Q - pQ\ln Q_{(-1)} - wx_{(-1)}\ln Q_{(-1)} = 2xz + 2x\varepsilon$

$pQ\ln Q + xw_{(-1)}\ln Q - pQ\ln Q_{(-1)} = wx_{(-1)}\ln Q_{(-1)} + 2xz + 2x\varepsilon$

Let $a = p$, $b = xw_{(-1)}$, $c = \ln Q_{(-1)}$. LHS is as follows:

$aQ\ln Q + b\ln Q - acQ$

Assume $f(Q_0) = aQ_0\ln Q_0 + b\ln Q_0 - acQ_0$

The first partial derivative of $f(Q_0)$ with respect to Q_0 is:

$f`(Q_0) = a + a\ln Q_0 + (b/Q_0) - ac$

The second partial derivative of $f(Q_0)$ with respect to Q_0 is:

$f``(Q_0) = (a/Q_0) - (b/Q_0^2)$

Therefore, the second-order Taylor expansion around Q_0 can be written as:

$$\frac{f(Q_0)}{0!} + \frac{f'(Q_0)}{1!}(Q - Q_0) + \frac{f''(Q_0)}{2!}(Q - Q_0)^2$$

$$= aQ_0\ln Q_0 + b\ln Q_0 - acQ_0 + (a + a\ln Q_0 + \frac{b}{Q_0} - ac)(Q - Q_0) + \tfrac{1}{2}(\frac{a}{Q_0} - \frac{b}{Q_0^2})(Q - Q_0)^2$$

Taking the expected value of LHS, we obtain:

$$E[\frac{f(Q_0)}{0!} + \frac{f'(Q_0)}{1!}(Q - Q_0) + \frac{f''(Q_0)}{2!}(Q - Q_0)^2]$$

$$= aQ_0\ln Q_0 + b\ln Q_0 - acQ_0 - aQ_0 - aQ_0\ln Q_0 - b + acQ_0 + (a + a\ln Q_0 + \frac{b}{Q_0} - ac)E(Q_0) + \tfrac{1}{2}(\frac{a}{Q_0} - \frac{b}{Q_0^2})E(Q - Q_0)^2$$

By rearranging terms, the equation is as follows:

$$\mathrm{E}[\frac{f(Q_0)}{0!}+\frac{f'(Q_0)}{1!}(Q-Q_0)+\frac{f''(Q_0)}{2!}(Q-Q_0)^2]$$

$$=b\ln Q_0-aQ_0-b+(a+a\ln Q_0+\frac{b}{Q_0}-ac)E(Q)+\tfrac{1}{2}(\frac{a}{Q_0}-\frac{b}{Q_0^2})E(Q-Q_0)^2 \quad (1)$$

Kastens and Brester defined E(Q) as:

E(Q)=

$$\frac{-b\ln Q_0+aQ_0+b+\frac{1}{2}\left(\frac{b}{Q_0^2}-\frac{a}{Q_0}\right)E(Q_0-Q_0)^2+xw_{(-1)}\ln Q_{(-1)}+2xz}{a+a\ln Q_0+\frac{b}{Q_0}-ac}+\frac{2x}{a+a\ln Q_0+\frac{b}{Q_0}-ac}E(\varepsilon)$$

They dropped the last term of the above equation because the expected value of the error term, E(ε), is zero. They also assumed that the expected value of Q is Q_0 (i.e., E(Q) = Q_0). Their equation is as follows:

$$\frac{b-aQ_0}{2aQ_0^2(1+\ln Q_0-c)+bQ_0}E(Q-Q)^2+\frac{b(1-\ln Q_0)+aQ_0+xw_{(-1)}\ln Q_{(-1)}+2xz}{a+a\ln Q_0+\frac{b}{Q_0}-ac}-Q_0=0$$

The final equation shown in Kastens and Brester's study is as follow:

$$\frac{xw_{(-1)}-pQ_0}{2pQ_0^2(1+\ln Q_0-\ln Q_{(-1)})}E(Q-Q)^2+\frac{xw_{(-1)}(1-\ln Q_0+\ln Q_{(-1)})+pQ_0+2xz}{p(1+\ln Q_0-\ln Q_{(-1)})+\frac{xw_{(-1)}}{Q_0}}-Q_0=0$$

We derived equation (1) differently. Recall that the equation is as follows:

$$b\ln Q_0-aQ_0-b+(a+a\ln Q_0+\frac{b}{Q_0}-ac)E(Q)+\tfrac{1}{2}(\frac{a}{Q_0}-\frac{b}{Q_0^2})E(Q-Q_0)^2$$

After taking the expected value of RHS, we obtain:

$$b\ln Q_0-aQ_0-b+(a+a\ln Q_0+\frac{b}{Q_0}-ac)E(Q)+\tfrac{1}{2}(\frac{a}{Q_0}-\frac{b}{Q_0^2})E(Q-Q_0)^2-2xz-2xE(\varepsilon)=0$$

Because E(ε) = 0, the previous equation can be written as:

$$b\ln Q_0-aQ_0-b+(a+a\ln Q_0+\frac{b}{Q_0}-ac)E(Q)+\tfrac{1}{2}(\frac{a}{Q_0}-\frac{b}{Q_0^2})E(Q-Q_0)^2-2xz=0$$

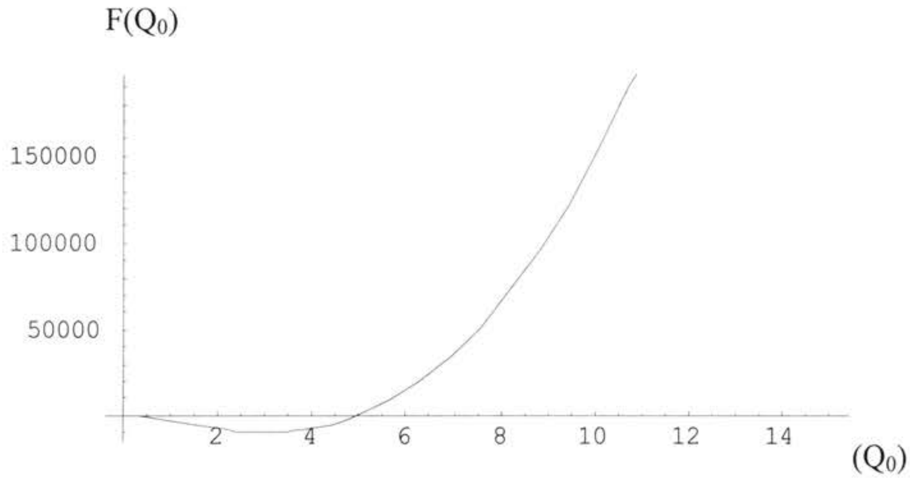
Consistent with Kastens and Brester's derivation, we assumed E(Q) = Q_0

$$b\ln Q_0 - aQ_0 - b + aQ_0 + aQ_0\ln Q_0 + b - acQ_0 + \left(\frac{aQ_0 - b}{2Q_0^2}\right)E(Q-Q_0)^2 - 2xz = 0$$

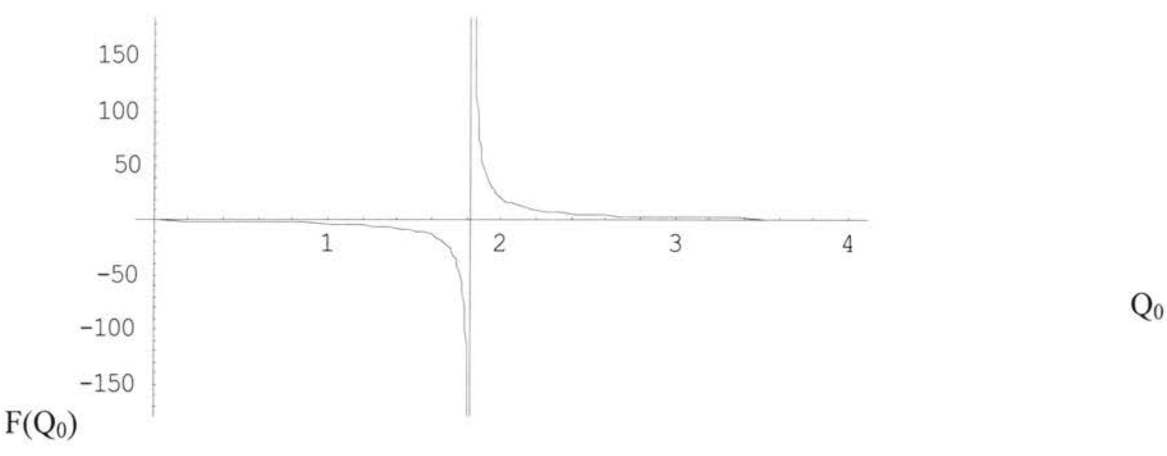
By multiplying the above equation by $2Q_0^2$, we obtain

$$2bQ_0^2\ln Q_0 + 2aQ_0^3\ln Q_0 - 2acQ_0^3 + (aQ_0 - b)E(Q-Q_0)^2 - 4xzQ_0^2 = 0 \quad (3)$$

The graph of $f(Q_o)$ (from equation 3) vs. Q_0, using our derivation, is as follows:



The graph of $f(Q_0)$ (from equation 2) vs. Q_0, using Kastens and Brester's derivation, is as follows:



Note: The values of p, lnQ(-1), x, and w in the above two graphs are not the same.

VITA

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