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Price and Quality Effects of Generic Advertising: The Case of Norwegian Salmon

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Price and Quality Effects of Generic Advertising: The Case of Norwegian Salmon

Abstract

In this paper, a two-equation sample selection model is used to estimate a household demand function for salmon incorporating domestic generic advertising. The two-equation estimation procedure, based on purchase and unit value equations, allows us to handle heavily censored panel data for salmon purchases by Norwegian households and the quality effects simultaneously. Unit values of the aggregated salmon commodity calculated from the observed expenditures and quantities are hypothesized to represent the average quality of the purchased commodity. Advertising effects on both purchases and unit values are investigated. The model also allows us to separate the effects of conditional purchases and purchase probabilities. Results indicate that most (78%) of the advertising effect is through the change of non-purchase occasions to purchase occasions, and that generic salmon advertising induces Norwegian households to spend more money on salmon. However, advertising causes households to select more expensive products rather than increasing their purchased quantities.

Price and Quality Effects of Generic Advertising: The Case of Norwegian Salmon

Generic advertising and promotion has become an important marketing tool for many agricultural commodities in the United States and other countries, and has been widely investigated in the agricultural economics literature (Ferrero et al; Hurst and Forker). These studies typically can be divided into two types: positive or normative. The positive studies have focused on evaluating the impact of generic advertising and promotion on markets. The normative studies have generally examined the optimal allocation of checkoff funds.

The majority of these studies have relied upon highly aggregated market-level data for econometric estimation. However, more recently, there have been several studies that have utilized micro-level household data. For example, Schmit et al. (2002; 2003) used household data on fluid milk and cheese purchases to estimate the impact of generic dairy advertising on the household demand for dairy products. Ward measured the impact of the U.S. beef checkoff program using household data. Richards used purchase occasion household data to measure the impact of fruit advertising. A key advantage of household data relative to market data is the former allows one to examine the impact of demand factors on household behavior, which is more consistent with the theory of consumer utility maximization. For example, the use of household data allows the researcher to investigate whether the impact of advertising primarily increases households' purchase incidence, or purchase amount. This cannot be done using market-level data. This type of information is valuable for marketing policy makers for crafting advertising strategies.

The purpose of this study is to demonstrate how the impacts of advertising can be decomposed into effects on the quantity and quality of purchases. Ignoring the distinction between quality and quantity of purchases may lead to erroneous inferences with respect to advertising in cross-sectional datasets.[1] The data are drawn from a panel survey of 1,516 Norwegian households provided by GfK Norge, a marketing research company. Unlike previous household-level advertising studies, we adopt an econometric model developed by Dong, Shonkwiler, and Capps to account for selectivity bias arising from non-consuming households and the resulting unobserved unit values (described in detail in the following section). The model allows the impact of advertising to be decomposed into its effect on quantity purchased and on the quality of products purchased by households. In addition, the model provides a measurement of the impact of advertising on household purchase incidence and quantity purchased.

Norwegian fish farmers have operated a mandatory checkoff program aimed at increasing fish consumption both domestically and abroad since 1979. Since Norway is a net exporter of seafood, this checkoff program is funded through a mandatory levy on all seafood exports, which have an annual gross value of approximately $4 billion. The annual advertising and promotion budget from the export levy is about $41 million, with the majority (97%) allocated to export promotion. However, since 1999, the Norwegian Seafood Export Council (NSEC), who manage the seafood checkoff program, has run an extensive domestic generic advertising campaign for salmon compared to earlier levels of advertising.

[1] There are arguments on how to define "quality" in the literature. Following Deaton, Theil, Houthaker, and Dong, Shonkwiler, and Capps, we use the term quality as a euphemism for product aggregation bias. Davis and Hewitt provide a good summary discussion of the relation between the different notions of quality.

There have been several economic studies conducted to evaluate the economic impacts of NSEC promotion activities, all of which have used market-level data. Economic evaluations of Norwegian salmon promotion have been conducted by Bjorndal et al., Kinnucan and Myrland (2000; 2002), and Myrland and Kinnucan. However, all of these studies have focused on export promotion activities since export markets are substantially more important than the domestic market in terms of producer revenue. Consequently, no empirical estimates of advertising effects exist for the domestic market.

Data Issues and Implications

Before introducing the econometric model, it is helpful to clarify some issues related to household demand estimation. In general, goods are purchased by households in elementary products and each product has its unique price. The consumer's utility maximization theory is based on the elementary products. However, in many circumstances, the research interest is only on consumer's choice of a broad commodity category rather than a specific elementary product. For example, we may want to model household demand for "meat" without distinguishing how much is beef, poultry, pork, etc. Under this situation, one must deal with the issue of product aggregation. There has been extensive work on product aggregation and its consequences in the literature. Product aggregation involves the separability concept that, in general, contains two situations: Hicksian separability, which imposes constraints on price movements, and functional separability, which imposes constraints on the structure of preferences. Since the discussion of this issue is beyond the scope of this study, we focus only on the justification of the use of the unit value to replace the unobserved price in the aggregated household demand estimation when using household purchase data.

Suppose x_j^i is an individual salmon product *j* demanded by household *i*, and p_j is its associated observable market price, where j = 1, 2, 3,…, *n*, and *n* represents the total number of individual salmon products that can be chosen by the households. Under the condition of functional (weak) separability of salmon products from others, the consumer's utility maximization problem is given by:

$$(1)\qquad \begin{aligned} &\max \quad U(x_1, x_2, \cdots, x_n) \\ &\quad s.t. \sum_{j=1}^{n} p_j x_j = E \end{aligned}$$

where *E* is total expenditures on salmon products. In this study, we are interested in the aggregated salmon commodity not on any specific product. The aggregated salmon commodity demanded by household *i* is:

$$(2)\qquad Q_i = \sum_{j=1}^{n} x_j^i \, .$$

However, the price of the aggregated commodity Q_i is not observable. In practice, researchers use the unit value of the aggregated commodity as a substitute for its price, which is derived by dividing expenditures by the aggregated quantity:

$$(4)\qquad V_i = \frac{E_i}{Q_i} \, ,$$

where: E_i is the expenditure of salmon devoted by household *i*, which equals $\sum_{j=1}^{n} p_j x_j^i$.

As discussed below, this derived unit value of the commodity varies not only with the genuine price of the commodity, but also with the composition of the quantities of the elementary products chosen by the household.

Assuming prices of all individual products in the salmon commodity vary proportionally (Hicksian separability) as proposed by Deaton, they can be expressed as

(3) $$p_j = P \cdot p_j^*,$$

where: P can be thought of as the level of salmon prices of Q_i, and p_j^* is a quality indicator of x_j, the individual salmon product j, which is determined by its attributes.[2] The larger p_j^* the higher the quality of x_j. Both P and p_j^* are unobservable and exogenous to consumers. Since P is the genuine price index of the salmon commodity, it varies only across time and regions based on transfer costs. If two households purchase salmon products in the same region at the same time, they will face the same P, even though they may purchase different salmon products. However, p_j^* is dependent on individual salmon products. For example, p_j^* for the fresh salmon is higher than that for frozen salmon, but they both have the same P.

If we rewrite (3) by taking into account (2) and (4), we have:

(5) $$V_i = P \cdot W_i,$$

where $W_i = \frac{\sum_{j=1}^{n} p_j^* x_j^i}{\sum_{j=1}^{n} x_j^i}$, which is the measure of the aggregated commodity's quality, and it depends on the composition of household i's purchases of the individual salmon products

[2] As pointed out by Nelson, P is actually the price level of the Hicksian composite commodity defined as $Q_i^c = \sum_{j=1}^{n} p_j^* x_j^i$. Since Q_i^c is not observable, we follow Deaton using Q_i .

(x's). This implies that W_i is endogenous and determined by households' purchasing choice. By expressing equation (5) in logarithmic form, the unit value becomes the sum of the price and quality index, i.e.:

(6) $$\ln V_i = \ln P + \ln W_i ,$$

Assuming that the salmon commodity forms a separable branch of preferences, the solution to the household utility maximization problem yields the demand for the individual salmon products as a function of the total salmon budget, the prices of the individual products, and the household specific characteristic variables. Consequently, the household demand for the aggregated salmon commodity from all the individual salmon products is also a function of total salmon expenditure *E*, all the prices of individual salmon products, and household characteristic variables *H*:

(7) $$Q_i = Q(p_1, p_2, \cdots, p_n, E_i, H_i) .$$

By considering (3) and (5), (7) can be written as:

(8) $$Q_i = Q(\ln V_i, E_i, H_i) .$$

In equation (7), all the variables are observed and the endogenous unit value V_i, according to (6), can be defined as:

(9) $$\ln V_i = f(H_i, C_i) ,$$

where: C_i is a vector of proxy variables for the unobserved price *P*, which can be regions, and H_i is used as a vector of proxy variables for the unobserved quality index W_i. Due to selectivity bias and the fact that unit value is endogenous, (8) and (9) must be estimated simultaneously.[3]

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[3] Deaton claims that "…there is no selectivity problem involved in estimating the unit value equation using only those households that make a market purchase…" However, according to Wales and Woodland this claim is incorrect.

From the estimation of (8) and (9), one can obtain the unit value elasticity of quantity (η_V^Q), the income elasticity of unit value (η_Y^V), and the income elasticity of quantity (η_Y^Q). From these elasticities, Deaton (1988) demonstrated how the price elasticity (η_P^Q) could be retrieved:

(10) $$\eta_P^Q = \frac{\eta_V^Q}{1 - \eta_V^Q(\eta_Y^V / \eta_Y^Q)}.$$

From the above analysis, it is clear that the commodity price (*P*) affects not only the demand quantity, but also the unit value. For example, if an increase in market prices moves the household to purchase less expensive salmon products, the change in the unit value will be smaller than the change in the price. Thus, if unit values are used as prices in the demand estimation, the same quantity difference will be ascribed to a smaller unit value difference due to the quality effect, and hence the "price elasticity" will be exaggerated (Deaton).

Econometric Model

An empirical version of equation (8) is specified as the following:

(11) $$Q_{it}^* = \ln V_{it}^* \alpha_1 + Z_{it}\alpha_2 + \varepsilon_{it},$$

where: Q_{it}^* is *i*th household purchase of salmon at time *t*, Z_{it}, the combination of H_i and E_i, is a vector of exogenous variables of household characteristics, demographic, socio-economic, and advertising, and $\ln V_{it}^*$ is the natural logarithm of the salmon unit value paid by household *i* at time *t*. Greek letters α_1 and α_2 are parameters to be estimated, and ε_{it} is the error term. There is no restriction imposed on equation (11), so Q_{it}^* can take either positive or negative values. However, in household survey data, the observed purchases take only non-negative values. We map the unrestricted "latent" variable Q_{it}^* to the non-negative observed purchase Q_{it} as below (Tobin):

$$(12) \qquad Q_{it} = \begin{cases} Q_{it}^*; & if\ Q_{it}^* > 0 \\ 0\ ; & \text{otherwise}\,. \end{cases}$$

The unit value equation defined in (9) can be specified as below:

$$(13) \qquad \ln V_{it}^* = \begin{cases} \ln V_{it}; & if\ Q_{it}^* > 0 \\ X_{it}\beta + e_{it}\ ; & \text{otherwise}\,, \end{cases}$$

where V_{it}^* is the latent unit value; V_{it} is the observed unit value; X_{it} is a vector of variables consisting of C_i and H_i; β is a vector of parameters, and e_{it} is the error term.

The error terms, ε_{it} and e_{it} in equations (11) and (13), are assumed to have a joint normal distribution with a mean vector zero and variance-covariance matrix as:

$$(14) \qquad \Omega = \begin{bmatrix} \sigma_{\varepsilon\varepsilon} & \sigma_{\varepsilon e} \\ \sigma_{e\varepsilon} & \sigma_{ee} \end{bmatrix}.$$

Following Dong, Shonkwiler, and Capps, the likelihood function of this model can be written as:

$$(15) \qquad L(Q, \ln V; \alpha, \beta, \Omega) = \prod_{+} \phi(\varepsilon_{it}, e_{it}; 0, \Omega) \prod_{0} \Phi(-\theta_{it})$$

where: $\phi(.)$ is the bivariate normal pdf of ε_{it} and e_{it} with zero mean and variance-covariance matrix of Ω. Note $e_{it} = \ln V_{it} - X_{it}\beta$ for purchased occasions with unit values being observed. The "+" and "0" below the product symbols indicate purchase and non-purchase occasions respectively. Factor $\Phi(-\theta_{it})$ is the standard univariate normal *cdf* evaluated at $-\theta_{it} = -[(X_{it}\beta)\alpha_1 + Z_{it}\alpha_2]/(\sigma_{\varepsilon\varepsilon} + 2\alpha_1\sigma_{\varepsilon e} + \alpha_1^2\sigma_{ee})^{\frac{1}{2}}$, which is the probability of zero-purchase for household *i* at time *t*. Model parameter estimates thus can be obtained by maximizing equation (15) or the logarithm of this equation.

Data

The data used in this paper are drawn from a panel survey of Norwegian households provided by GfK Norge, a marketing research company. The panel survey includes 1,516 Norwegian households, which is representative of the country. These households report on a weekly basis every shopping trip that is done within the given week. The data report the expenditure and quantity of each item. In addition to household demographics such as size, age, location and income, the type of store the purchase was made, day of purchase, and whether the item was on sale are also reported by each household.

The data used for estimation contains household purchase information for 12 salmon products categorized as fresh, frozen, smoked, sliced etc., on a weekly basis, including total expenditures and quantities. Since generic fish advertising data are recorded as monthly expenditures, the final purchase data are reformulated on a monthly basis and merged with the advertising data. The main objective of this analysis is to investigate the effects of advertising on Norwegian household salmon purchases. The total salmon commodity category is aggregated from many varieties in the data. The final data cover the years 1999 through 2001. Since not all the households participated in the survey in all the years, and about 80% of the observations (on a monthly basis) are non-purchase occasions for salmon, there is not enough information to conduct a formal panel structure analysis. However, the data can be pooled to provide enough observations to handle the heavily censored problem.

Advertising is considered to be a demand shifter in the marketing and economics literature. In this analysis, it is based on total monthly generic seafood advertising expenditures. To capture the carry-over effect of advertising, advertising expenditures are lagged nine months and a polynomial distributed lag model is adopted as follows (Clarke 1976):

(16) $$ADV\_X_t = \sum_{i=0}^{L} \omega_i A_{t-i} ,$$

where: A_{t-i} is the i^{th} lag of advertising at time t, L is the total lag length, which is nine in this case, and $\omega_i = \gamma_0 + \gamma_1 i + \gamma_2 i^2$ (i = 0, 1, …, L) are the quadratic weights of lagged advertising. Two restrictions are imposed on ω_i: (i) current advertising has the maximum weight, which is defined as one ($\omega_0 = 1$ as the maximum); (ii) the weight of the tenth lag is zero ($\omega_{10} = 0$), that is, the effect of advertising ends at the tenth month (i.e., has nine month lags' effect). After imposing restrictions (i) and (ii), we have $\omega_i = 1 - \frac{1}{(L+1)^2} i^2$. ADV_X_t, the sum of weighted advertising over the current and all the lags, is used as an explanatory variable in the demand and unit value equations. The coefficient of ADV_X_t then represents the long-run effect of advertising.

Income and age are recorded as group categories and are transformed into dummy variables. Table 1 provides an overview of the variables used in the empirical model.

Estimation Results

Maximum likelihood estimates of the model are obtained using the GAUSS software system. The optimization algorithm proposed by Berndt et al. is used for the estimation. The standard errors of the estimated coefficients are obtained from the inverse of the negative numerically evaluated Hessian matrix of (15). The estimated coefficients are presented in Table 2.

As discussed above, the data are pooled to gain enough observations for the heavily censored problem. However, in order to capture the temporal effects, a time trend is included in each equation as suggested by Wooldridge. The time trends are significant in both equations. The covariance of the errors in the two equations is insignificant. This does not imply that the purchase and the unit value have no correlation. The correlation between the two variables was introduced through the significant estimates of α_1, the coefficient of the unit value in the purchase equation.

From these coefficients, the elasticities of each explanatory variable can be computed. The use of unit value and the simultaneity issue makes the evaluation of elasticities complicated because the exogenous variables of household characteristics, demographic and social-economics not only have direct effects on household salmon purchases, but also have indirect effects through the changes in unit value. For example, an increase in household income gives the household more money to spend which may result in increased salmon purchases. However, the increase in household income may also allow the household to buy higher priced (i.e., higher quality) salmon products. The final effect of income on salmon purchases would depend upon the net of these two effects.

The expected values of purchase and unit value, based on how the elasticities are calculated, are derived as follows:

(17) $$E(Q_{it}) = \Phi(\theta_{it})[(X_{it}\beta)\alpha_1 + Z_{it}\alpha_2] + \omega_1\varphi(\theta_{it}) ,$$

(18) $$E(\ln V_{it}) = X_{it}\beta ,$$

where: $E(.)$ is expectation operation, $\Phi(.)$ is the standard normal *cdf* , and $\varphi(.)$ is the standard normal *pdf*, $\omega_1 = (\sigma_{\varepsilon\varepsilon} + 2\alpha_1\sigma_{\varepsilon e} + \alpha_1^2\sigma_{ee})^{\frac{1}{2}}$. Factor $\Phi(\theta_{it})$ is the probability of positive purchase for household *i* at time *t*. To compute the unit value effect on purchase, the expected value conditional on a given unit value is calculated as:

(19) $$E(Q_{it} \mid V_{it}) = \Phi(\delta_{it})[\ln V_{it}\alpha_1 + Z_{it}\alpha_2] + \omega_2\varphi(\delta_{it}),$$

where: $\delta_{it} = [\ln V_{it}\alpha_1 + Z_{it}\alpha_2 + \frac{\sigma_{\varepsilon e}}{\sigma_{ee}}(\ln V_{it} - X_{it}\beta)]/\omega_2$, and $\omega_2 = (\sigma_{\varepsilon\varepsilon} - \frac{\sigma_{\varepsilon e}^2}{\sigma_{ee}})^{\frac{1}{2}}$. Factor $\Phi(\delta_{it})$ is the probability of positive purchase for household *i* at time *t* given unit value V_{it}. Note the difference between $\Phi(\delta_{it})$ and $\Phi(\theta_{it})$.

Elasticities of explanatory variables evaluated at the sample mean with respect to equations (17)-(19) are presented in Table 3. A detailed explanation of how these elasticities are calculated is provided in the Appendix. The columns of *E(Q|V)*, *E(V)*, and *E(Q)* are the results with respect to equations (19), (18), and (17), respectively. Elasticities of *E(Q)* in column 3 can be viewed as a combined or total of the results from *E(Q|V)* (column 1) and *E(V)* (column 2). A detailed discussion on these elasticities is presented below.

Marketing Related Variables

The unit value elasticity is only available for the purchase equation when the unit value is given as indicated in equation (19).[4] Under this situation, the unit value elasticity is found to be negative (-1.84), statistically significant, and elastic as expected. A 1%

[4] Unit value is given can be interpreted as the unit value is fixed and the household is not allowed to adjust its purchase composition for quality.

increase in unit value reduces salmon purchases by 1.84%. As defined above, an increase in the salmon unit value can come from either the real increase of salmon market price, or by the choice made by households to buy higher priced or higher quality salmon products. Unfortunately, we are not able to identify the two sources of changes. However, the effect of the two types of change on demand can be treated as the same.

The results of advertising are quite interesting because of the separate quality and quantity effects. A 1% increase in advertising significantly increases salmon purchases by 0.17% when the unit value is given, i.e., when the quality effect is not taken into account. At the same time advertising increases the unit value of salmon by 0.06%. This increase in unit value, in turn, decreases the quantity of salmon purchases. Hence, the increase in unit value offsets the purchase effect induced by advertising. Thus the eventual increase in purchases becomes small and insignificant (0.04). Therefore, the total effect of advertising is found to be positive (but statistically insignificant) on quantity purchased, but advertising still has a statistically significant impact on increasing the salmon unit value or quality purchased by households. Consequently advertising increases total household expenditures on salmon. For instance, a 1% increase in advertising increases salmon purchase by 0.04% (insignificantly) and increases the unit value by 0.06% (significantly). As a result, the change in salmon expenditures is $(1+0.04)*(1+0.06) – 1 = 0.10\%$. This result implies that salmon advertising induces Norwegian households to spend more money on salmon.

Salmon purchases made in special fish shops or in other stores are found to have no significant difference on either quantity or unit value. However, store “on sale” promotions are found to play an important role in salmon purchases. The significant negative effect on unit value (-4.71) is because the stores' "on sale" program is always related to price reduction promotion. Thus the overall effect on salmon purchase is found to be positive and significant (0.02). However, the effect on purchase when unit value is given is found surprisingly to be negative and significant (-0.12). This unintuitive result may be interpreted as follows. A store's "on sale" activity increases salmon purchase only through the decrease in unit value. Under the "on sale" program, if the unit value is not allowed to change (i.e., no price reduction) and no quality adjustment is allowed, consumers would then reduce their willingness to purchase salmon.

Household Characteristics

Household income and age of the household head were collected as group categories, and their effects were estimated by dummy variables. Relative to households with income over 600,000, we found the incomes below 200,000, and between 250,000 and 300,000 have negative and significant effects on salmon purchases, while the incomes between 500,000 and 600,000 have significant positive effects. Relative to the age of 45-59, younger head households are found to purchase less salmon, while households with older heads purchase more. Household size is found to have positive effects, while the proportion of persons under 16 years of age have negative effect on salmon purchase. In contrast to $E(Q)$ in which all the effects are significant, the effects of *HSIZE* on $E(Q|V)$ are insignificant.

With respect to the unit value equation, incomes are insignificant. Household size is negative, as expected, implying that a large household would sacrifice quality for quantity of salmon purchases to satisfy the needs of additional people living in the household. Relative to the age of 45-59, younger head households purchase higher priced salmon, while older head households purchase lower priced products. The proportion of children under 16 years old in the household has a positive, but insignificant coefficient.

Regional Variables

Metropolitan and regional variables are not included in the purchase equation since they do not affect purchases when the unit value is given. However, they can indirectly affect the unconditional purchase through the change in the unit value. Indeed, without unit value given, *METRO* is found to significantly increase salmon purchases because it has a negative and significant effect on unit value. This result implies that residents in metropolitan areas either pay lower salmon prices or purchase lower quality products. Purchases are also found to be significantly different among regions.

No significant effects are found for regions in both purchase and unit value equations.

Extensive and Intensive Responses of Salmon Purchases

The elasticities in Table 3 with respect to purchases can be decomposed into two parts: intensive and extensive responses. The intensive response of purchase is the continuous adjustments in purchased quantity when the explanatory variables change after a positive purchase occurs. The extensive response is the discrete change between purchase and non-purchase occasions. The two types of responses for several key variables are provided in Table 4. Column 1 gives the elasticities of conditional purchase when unit values are given, which represent the intensive effects. Column 2 lists the elasticities of the probability of positive purchases when unit values are given, which represent the extensive effects. Columns 3 and 4 are the results when unit values are not given.

The overall advertising elasticity without given unit values is 0.04. This can be decomposed into an intensive elasticity of 0.01 (column 3 in Table 4) and an extensive elasticity of 0.03 (column 4 in Table 4). The results indicate that most of the advertising effects on salmon purchases (78%) are through extensive effects, i.e., through the change of non-purchase occasions to purchase occasions. Indeed, this pattern is found for all other variables in Table 4, which is consistent with the household data that about 80% of the observations are non-purchase occasions.

Concluding Comments

In this study, the impact of generic salmon advertising on household demand in Norway was evaluated. The data included 1,516 Norwegian households on a monthly time interval from 1999-2001 provided by GfK Norge, a marketing research company. Unlike previous household-level advertising studies, we used an econometric model designed to account for selectivity bias arising from non-consuming households and the resulting unobserved unit values. One advantage of the model was it provided for a decomposition of advertising impacts on both quality and quantity demanded by households. In addition, the model provided a measurement of the impact of advertising on household purchase incidence and quantity purchased.

The findings in this paper are interesting both from a marketing perspective, and from commodity policy perspective. While domestic salmon advertising appears to not have a significant impact on increasing demand, it does have a positive effect on quality. That is, advertising induces Norwegian households to purchase more expensive, higher quality salmon products. A 1% increase in advertising increased the unit value of salmon by 0.06%. Consequently, salmon advertising increased total household expenditures on salmon. A 1% increase in advertising resulted in a 0.10 percent increase in household salmon expenditures. The intensive and extensive impacts of advertising were also estimated. The overall advertising elasticity of household purchases without given unit values was 0.04. This elasticity was decomposed into an intensive elasticity (increase in purchase quantity) of 0.01 and an extensive elasticity (increase in purchase occasions) of 0.03. Thus, the results indicated that most of the advertising effects on salmon purchases (78%) are through extensive effects. Indeed, this pattern was found for all other variables in the demand model.

Table 1. Explanatory Variables Used in Purchase and Unit Value Equations

Name	Description (unit)	Means
Marketing Related Variables		
QUANTITY	*Monthly purchase of salmon (gram)*	265.07[5]
PRICE	*log of price*	13.959
ADV_X	*polynomial distribution lag of advertising (1,000,000)*	5.0942
FISHSHOP	*dummy of fish shop (0/1)*	0.0321
ONSALE	*dummy of price on sale (0/1)*	0.2319
Household Characteristics		
INCOME1	*hh income between 0-100 (0/1)*	0.0401
INCOME2	*hh income between 100-200 (0/1)*	0.1376
INCOME3	*hh income between 200-250 (0/1)*	0.1127
INCOME4	*hh income between 250-300 (0/1)*	0.1276
INCOME5	*hh income between 300-350 (0/1)*	0.1047
INCOME6	*hh income between 350-400 (0/1)*	0.0849
INCOME7	*hh income between 400-450 (0/1)*	0.0919
INCOME8	*hh income between 450-500 (0/1)*	0.0761
INCOME9	*hh income between 500-600 (0/1)*	0.1356
INCOME10	*hh income between 600+ (0/1)*	0.0888
HSIZE	*log of hh size*	0.6873
AGE_HEAD1	*head age between 16-24 (0/1)*	0.0043
AGE_HEAD2	*head age between 25-44 (0/1)*	0.2872
AGE_HEAD3	*head age between 45-64 (0/1)*	0.4497
AGE_HEAD4	*head age between 65+ (0/1)*	0.2588
KID16_PROP	*proportion of persons under 16*	0.0976
Regions		
METRO	*dummy versus rural (0/1)*	0.7890
NORTH	*region dummy (0/1)*	0.1064
CENTRAL	*region dummy (0/1)*	0.1463
WEST	*region dummy (0/1)*	0.1811
OSLO	*region dummy (0/1)*	0.1551
Time Trend		
MONTHNUM	*Time trend of month*	--

[5] The number is the average over all the households. The average among purchase household is 1,044 G. These numbers are quite consistent with the measurement from other data.

Table 2. Maximum Likelihood Estimates of Model Parameters

Variable	Demand Equation (*Q*)		Price Equation (*lnV*)	
	Coefficient	Std. Error	Coefficient	Std. Error
CONSTANT	3.6191*	0.9929	2.7811*	0.0459
Marketing Related Variables				
PRICE (α_1)	-1.9368*	0.3754	--	--
ADV_X	0.3428*	0.1185	0.1215*	0.0412
FISHSHOP	0.0743	0.1171	-0.0434	0.0485
ONSALE	-0.5798*	0.1346	-0.3460*	0.0179
Household Characteristics				
INCOME1	-0.3989*	0.1356	0.0084	0.0501
INCOME2	-0.4134*	0.0945	-0.0084	0.0374
INCOME3	-0.1022	0.0965	0.0230	0.0370
INCOME4	-0.2270*	0.0892	-0.0202	0.0357
INCOME5	-0.0055	0.1007	0.0602	0.0373
INCOME6	0.0787	0.0958	0.0313	0.0372
INCOME7	-0.1188	0.0905	0.0046	0.0374
INCOME8	0.3665*	0.0967	0.0368	0.0375
INCOME9	0.0410	0.0839	-0.0245	0.0338
HSIZE	0.0001	0.0711	-0.1110*	0.0246
AGE_HEAD1	-1.1390*	0.5461	0.0857	0.2358
AGE_HEAD2	-0.3133*	0.0670	0.0604*	0.0243
AGE_HEAD4	0.2831*	0.0663	-0.1099*	0.0191
KID16_PROP	-0.3473*	-0.1601	0.0034	0.0144
Regions				
METRO	--	--	-0.1237*	0.0198
NORTH	--	--	-0.0310	0.0258
CENTRAL	--	--	-0.0043	0.0211
WEST	--	--	0.0367	0.0203
OSLO	--	--	-0.0131	0.0205
Time Trend				
MONTHNUM	0.0081*	0.0033	-0.0039*	0.0011
Variances Matrix				
	ε		e	
ε	1.8149*	0.0155	0.0559	0.1289
E	0.0559	0.1289	0.5828*	0.0073
*Goodness of fit measures (R2)***	0.1548		0.2483	

"*" indicates significance at the 0.05 level or higher.

"**" These measures are calculated through the squared correlation of actual and predicted values.

Table 3. Elasticities with respect to the Demand and Unit Value

Variable	*E (Q|V)* (1)		*E (V)* (2)		E (*Q*) (3)	
	Elasticity	T-ratio*	Elasticity	T-ratio*	Elasticity	T-ratio*
Marketing Related Variables						
PRICE	-1.8362	-5.5566	--	--	--	--
ADV_X	0.1656	2.7793	0.0619	2.9700	0.0444	1.0046
FISHSHOP	0.0175	0.6278	-0.6830	-0.9134	0.0372	1.4669
ONSALE	-0.1227	-4.5740	-4.7082	-16.480	0.0210	2.0540
Household Characteristics						
INCOME1	-0.0869	-3.0256	0.1363	0.1679	-0.0902	-3.1017
INCOME2	-0.0898	-4.3469	-0.1340	-0.2232	-0.0865	-4.3524
INCOME3	-0.0234	-1.0595	0.3739	0.6222	-0.0330	-1.6027
INCOME4	-0.0508	-2.5259	-0.3216	-0.5632	-0.0421	-2.1767
INCOME5	-0.0013	-0.0541	0.9985	1.6183	-0.0276	-1.3626
INCOME6	0.0185	0.8195	0.5114	0.8415	0.0042	0.2004
INCOME7	-0.0271	-1.3120	0.0746	0.1236	-0.0289	-1.5137
INCOME8	0.0905	3.7385	0.6035	0.9818	0.0708	3.2005
INCOME9	0.0096	0.4890	-0.3896	-0.7215	0.0206	1.1455
HSIZE	0.0290	0.4578	-0.1110	-4.4473	0.1744	3.3568
AGE_HEAD1	-0.2212	-2.5122	1.4404	0.3484	-0.2520	-3.8503
AGE_HEAD2	-0.0692	-4.7917	1.0019	2.4482	-0.0932	-7.3400
AGE_HEAD4	0.0690	4.1300	-1.6747	-5.8473	0.1224	9.0225
KID16_PROP	-0.0290	-1.5592	0.0119	1.8898	-0.0435	-2.8283
Regions						
METRO	--	--	-1.8732	-5.8004	0.0570	4.8368
NORTH	--	--	-0.4917	-1.2140	0.0139	1.1873
CENTRAL	--	--	-0.0692	-0.2046	0.0019	0.2040
WEST	--	--	0.6022	1.7858	-0.0162	-1.7653
OSLO	--	--	-0.2101	-0.6429	0.0059	0.6331

"*"The t-statistics are based on the standard errors derived from the Delta Method (Rao, 1973).

Table 4. Intensive and Extensive Responses of Salmon Purchases

Variable	*E (Q|Q>0, V)* (1)		*Prob (Q|Q>0, V)* (2)		*E (Q|Q>0)* (3)		Prob (*Q*>0) *(4)*	
	Elas.	T-ratio*	Elas.	T-ratio*	Elas.	T-ratio*	Elas.	T-ratio*
PRICE	-0.4266	-6.0237	-1.4096	-5.5161	--	--	--	--
ADV_X	0.0385	2.5423	0.1271	2.8342	0.0102	0.9010	0.0342	1.0263
HSIZE	0.0289	0.3851	0.0001	0.0020	0.0401	2.9615	0.1343	3.2598

"*"The t-statistics are based on the standard errors derived from the Delta Method (Rao, 1973).

Appendex: Elasticity Evaluation

If S is a function of a, say, $S = g(a)$, the elasticity of S with respect to a is the percentage change of S given a percentage change of a. It can be expressed as

$$\text{(A1)} \quad \eta_a^S = \frac{\frac{\Delta S}{S}}{\frac{\Delta a}{a}} = (\frac{\Delta S}{\Delta a})(\frac{a}{S}),$$

where Δ indicates a small change. However, the precisely definition of η_a^S can be given as:

$$\text{(A2)} \quad \eta_a^S = (\frac{\partial S}{\partial a})(\frac{a}{S}),$$

where $\frac{\partial S}{\partial a}$ is the derivative of S with respect to a. If a is a dichotomous variable, the elasticity then defined as: $\eta_a^S = g(1) - g(0)$, where $g(1)$ is the value of S when a = 1, and $g(0)$ is the value of S when a = 0.

Given equations (17)-(19), we can calculate several elasticities that are interested to us.

Quantity Elasticities

Equation (17) represents the unconditional expected value of the quantity purchased by households, which can be expressed as:

$$\text{(A3)} \quad E(Q_{it}) = Prob(Q_{it} > 0) \cdot E(Q_{it} \mid Q_{it} > 0)$$
$$= \Phi(\theta_{it})\{[(X_{it}\beta)\alpha_1 + Z_{it}\alpha_2] + \omega_1 \frac{\varphi(\theta_{it})}{\Phi(\theta_{it})}\},$$

where,

$$\text{(A4)} \quad Prob(Q_{it} > 0) = \Phi(\theta_{it}),$$

the probability of positive purchase, and

(A5) $$E(Q_{it} \mid Q_{it} > 0) = [(X_{it}\beta)\alpha_1 + Z_{it}\alpha_2] + \omega_1 \frac{\varphi(\theta_{it})}{\Phi(\theta_{it})},$$

the conditional expected value of the quantity given a positive purchase. According to (A2), the elasticity of unconditional quantity given in (A3) with respect to a particular exogenous variable c_{it} in Z_{it} or X_{it}, can be derived as:

(A6) $$\eta_c^Q = (\frac{\partial E(Q_{it})}{\partial c_{it}})(\frac{c_{it}}{E(Q_{it})}).$$

To get (A6), we need the derivatives of $\Phi(\theta_{it})$ and $\varphi(\theta_{it})$, which can be found in Maddala (1983). (A6) gives the results of Column (3) in Table 3, which are evaluated at the sample means. Similarly, we can derive the elasticity of the probability of positive purchase based on (A4), which gives the results of column (4) in Table 4, and the elasticity of conditional quantity based on (A5), which gives the results of column (3) in Table 4. Since (A3) is the product of (A4) and (A5), it implies that the elasticity of (A3) is the sum of the elasticities of (A4) and (A5). That is, the sums of the results in columns (3) and (4) in Table 4 are the results of column (3) in Table (3).

Since the unit value (*V*) is endogenized in this study, the expected value of the quantity purchased in (A3) does not depend on *V* directly. In order to compute the direct effect of the unit value on the quantity purchased, we need the expected value of quantity conditional on a given unit value, which is given by equation (19):

(A7) $$\begin{aligned} E(Q_{it} \mid V_{it}) &= Prob(Q_{it} \mid Q_{it} > 0, V_{it}) \cdot E(Q_{it} \mid Q_{it} > 0, V_{it}) \\ &= \Phi(\delta_{it})\{[(\ln V_{it}\alpha_1 + Z_{it}\alpha_2] + \omega_2 \frac{\varphi(\delta_{it})}{\Phi(\delta_{it})}\} \end{aligned}.$$

Then, the elasticity of quantity conditional on a given unit value with respect to a particular exogenous variable c_{it} (V_{it} or any variable in Z_{it}) can be derived as:

(A8) $$\eta_c^{Q|V} = (\frac{\partial E(Q_{it} \mid V_{it})}{\partial c_{it}})(\frac{c_{it}}{E(Q_{it} \mid V_{it})}).$$

(A8) gives the results of Column (1) in Table 3. Similarly, we can derive the elasticity of the probability of positive purchase conditional on a given unit value, which gives the results of column (2) in Table 4, and the elasticity of quantity conditional on a positive purchase and a given unit value, which gives the results of column (1) in Table 4. Similarly, the sums of the results in columns (1) and (2) in Table 4 are the results of column (1) in Table (3).

According to (A1), we can numerically evaluate (A6) and (A8). Take (A6) as an example. We calculate $E(Q_{it})$ using (A6) at the original value a (usually the mean value) of a particular variable, say household size. Then, after given a small change in the variable, say Δa = 0.001, we calculate the new value of $E(Q_{it})$ using (A6). According to (A1), the elasticity can be evaluated as: $\eta_a^Q = \frac{\frac{\Delta E(Q_{it})}{E(Q_{it})}}{\frac{\Delta a}{a}}$. Similarly, this approach can be applied to (A8). This approach has been used widely since one does not need to analytically calculate the derivatives of (A3) and (A5). The results reported in Tables 3 and 4 are computed from this numerical procedure.

Unit Velue Elasticities

The expected value of the logarithm unit value is given by (18), i.e.,

(A9) $$E(\ln V_{it}) = X_{it}\beta .$$

The elasticity of V_{it} with respect to X_{it} then is:

(A10) $$\eta_X^V = \frac{\beta}{E(V_{it})}.$$

(A10) gives the results of column (2) in Table 3.

In this two-equation model, the marginal effects on the quantity (captured by (A6)) of a variable that is common in both equations can be viewed as the sum of the direct effects of the unit value (captured by (A8)) on the quantity and the indirect effects of the variable through the change of the unit value (captured by (A10)).

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