Consumer Structure of the Blueberry Market: A Double Hurdle Model Approach

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Abstract

Rapid growth has been observed in the fresh blueberry market since 2000, but at the same time, there is no obvious consumption increase in the market for frozen blueberries. In this study, we analyze the different consumer structures in the fresh and frozen blueberry markets by classifying consumers into “buyers”, “potential buyers” and “non-buyers” of blueberries. A double hurdle count data model is used. The results show that while the fresh blueberry market is mainly composed of buyers, most of the consumers in the frozen blueberry market are non-buyers. The difference in growth trends may be due to the fact that it is more difficult to convert non-buyers to buyers than to increase consumption of buyers.

Key Words: Fresh and Frozen Blueberry, Double Hurdle Count Data Model, Consumer Structure

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Introduction

Per capita consumption of fresh blueberries has increased dramatically since 2000 (USDA, Economic Research Service Calculations). However, per capita consumption of frozen blueberries has not shown big increasing trend since 1992. As illustrated by Figure 1, while per capita consumption of frozen blueberries was greater than that of fresh ones during the 1990's, the consumption of fresh blueberries has dominated the fresh and frozen blueberry market since 2002. To investigate why there is such a large deviation in the consumption trend of these two types of blueberries, it is useful to study differences on the consumer side for the two markets.

Fruit consumption can be affected by many objective and subjective factors. For example, most fruits are seasonal food. As such, the quantity of fruits on the market in the low season is usually much lower than in the peak season, which leads to the price differences over the year. Though some fruit may be available in what is the traditional "off-season" (due to global sourcing), some people may not consume at that time and may only consume during the peak season because of higher quality, lower price and/or habit. Thus, seasonality may be regarded as a "non-permanent' factor for non-consumption because its effect would be weakened under certain conditions. On the other hand, there are factors, such as allergies, taste preferences, distrust in quality, or diet constraints that may prevent consumers from consuming, regardless of season. These factors should be considered differently from factors like seasonality since

consumers affected by such factors don't change their consumption behavior easily. These factors can be regarded as relatively stable.

In their work on hurdle count data models in recreational analysis, Shonkwiler and Shaw (1996) classified people into three categories in terms of trip decisions: "non-participant", "potential participant" and "participant". In this study, we apply the same concept and divide the population into "non-buyer", "potential buyer" and "buyer" of blueberries. Non-buyers are defined as those who choose not to consume because of relatively stable reasons like allergies, tastes, preferences, etc. Potential buyers are not current buyers due to a temporary reason such as seasonality, but may consume in the future. Buyers are those who are consuming in the current period. Therefore, both potential buyers and non-buyers would have zero observations when the data is collected, though their consumption behaviors are different. Such consumer classification not only helps enhance our insight into the consumer structures of the fresh and frozen blueberry market, but also provides us with a new point of view in comparing markets with different growth patterns.

The objective of this study is to explain the different trends of the consumption volume of fresh and frozen blueberries by exploring potential differences in their consumer structures and show that the double hurdle model is quite useful in differentiating market growth patterns by classifying consumer types. The results will allow blueberry producers and retailers to gain insight into the existence of different consumer structures in different blueberry markets, so that they can develop separate and effective promotion strategies targeting non-buyers, potential buyers and buyers.

Literature Review

Since Cragg (1971), the double hurdle model has been extensively used in social science research. It has been applied to a wide variety of situations. Mishra, Williams, and Detre (2009) employed a double hurdle model to explore farm households' adoption of the internet to make purchases. Shonkwiler and Shaw (1996) introduced several count data hurdle models in the context of recreational demand. The adoption of the hurdle model is also widespread in studying food consumption behavior in agriculture economics. Batte et al. (2007) applied the model on consumers' perception about multi-ingredient processed organic food with different levels of organic content and food with other attributes, such as pesticide free, enhanced flavor, GM free and locally grown. It also has been applied to the consumption of tobacco and cigarettes (Jones, 1989; Aristei and Pieroni, 2008), milk (Dong and Kaiser, 2008), cheese (Yen and Jones, 1997; Gould, 1992), beef or steak (Schroeder et al., 2007; Maynard et al., 2004), rice (Gao, Wailes, and Cramer, 1995), fresh organic produce (Zhang, Huang, and Lin, 2006) and seafood (House, Hanson, and Sureshwaran, 2003; Zhang et al. 2004).

Although it's quite intuitive to assume that there is correlation between these two hurdles, a fairly large amount of literature found the correlation insignificant. Such literature includes Schroeder et al. (2007), Blaylock and Blisard (1992), Burton, Tomlinson, and Young (1994), Yen and Jones (1997) and Aristei and Pieroni (2008). Smith (2003) argued that the assumption of non-zero correlation between the two processes was spurious. However, Zhang, Huang, and Lin (2006) found that the generalized double-hurdle model outperformed the independent double hurdle model by

allowing the residuals from the participation process and consumption process to be correlated.

Most previous literature that applied the double hurdle model focused mainly on the discussion of the two decision stages of consumers (participation and consumption). However, we use the estimation results to analyze consumer structure. The goal of this approach is not only to develop an understanding of the participation and consumption decisions, but also to differentiate between consumers that participate at various points in time from those that choose to not participate for extended periods of time. Additionally, as pointed out by Cragg (1971), if zero consumption is allowed in the second hurdle, the sequence of the two hurdles in causing zero observations cannot be identified. Since it's quite plausible, even common that some consumers may not purchase at various times for various reasons such as an unexpected rise in price, or the product being of lower than expected quality, we allow zero purchases in the consumption stage even though the participation stage is crossed. Therefore, in addition to the valuable insights into the market growth pattern, our discussion, which is based on the analysis of consumer types, would also avoid potential ambiguity in interpretation.

The Data

An online survey about consumers' blueberry consumption was conducted with a random panel of respondents recruited by Survey Sampling, Inc. Data collection began in September 2010 and is expected to last until August 2011, with approximately 350 participants recruited on a monthly basis. The target respondents are primary shoppers in the northeast and southeast states of the U.S. In this version of the study, data from

September 2010 - February 2011 are used. A later version will contain the entire dataset.

Due to the difficulty in collecting the non-uniform prices over the seasons and across different purchase locations, purchase frequency information is used to represent the consumption amount for each household. In the survey, we first asked whether the respondent had ever purchased fresh or frozen blueberries and then asked whether they had purchased fresh or frozen blueberries in the month before the survey was taken. For those respondents who had purchased in the prior month, we asked them how many times they purchased, separately for fresh and frozen blueberries. We only asked purchase information for the month before the survey was taken to ensure accuracy of the data as it is usually difficult for people to recall purchases more than one month ago.

Demographic information is also collected. For the participation stage, we include diet constraint, income, race, gender, education level, awareness of the health benefits of blueberries, age, household size, and states as the explanatory variables. For the consumption stage, the same set of demographic information used in the participation stage and 5 dummies for months are used (Table 1).

The Theoretical Model

Cragg (1971) first proposed the double hurdle model as a generalization of the Tobit model by allowing the possibility that a factor might have different effects on the probability of acquisition and the magnitude of acquisition. When the model is applied to consumption decisions, it divides the decision into two stages: the participation stage (whether or not to purchase) and the consumption stage (how much/many to purchase).

A variable might have different or even opposite effects in these two decision stages. By contrast, the Tobit model imposes the constraint that a factor has an identical effect (both in magnitude and sign) in these two stages. Such a constraint does not hold in many circumstances. The double hurdle model also allows the two stages to include different explanatory variables.

Since the consumption of fruits demonstrates substantial diversity and seasonality, it's common to have many zero observations during certain periods. The specification of the double hurdle model provides us with an intuitive way to deal with excess zeroes and most importantly, it is well-suited for consumer classification. All three categories of consumers can be identified in the double hurdle model (Shonkwiler and Shaw, 1996).

The model specification for the double hurdle model is as follows:

1) The participation stage:

$$D_i = Z_i\alpha + \mu_i \qquad D_i = \begin{cases} 1 \; if \; Z_i\alpha + \mu_i > 0 \\ 0 \; if \; otherwise \end{cases} \tag{1}$$

2) The consumption stage:

$$Y_i^* = X_i\beta + \varepsilon_i \tag{2}$$

$$Y_i = 0 \quad if\{Z_i\alpha + \mu_i \le 0 \,\&\, X_i\beta + \varepsilon_i > 0\} \tag{3}$$

$$or\{Z_i\alpha + \mu_i > 0 \,\&\, X_i\beta + \varepsilon_i \le 0\} \tag{4}$$

$$or\{Z_i\alpha + \mu_i \le 0 \,\&\, X_i\beta + \varepsilon_i \le 0\} \tag{5}$$

$$Y_i = Y_i^* \quad if\{Z_i\alpha + \mu_i > 0 \,\&\, X_i\beta + \varepsilon_i > 0\} \tag{6}$$

Where D_i is the binary dependent variable indicating whether or not participation occurs. Y_i is the observed purchase frequency and Y_i^* is the latent dependent variable. Z_i and X_i are the vectors of explanatory variables in the two hurdles respectively. α and β are the

vectors of coefficients to be estimated. μ_i and ε_i are the error terms. The dependent variables in both stages can be zero. Therefore, in order to reveal a positive consumption amount, two hurdles have to be crossed.

Consumers identified in equation (6) are buyers; those identified in equation (3) and (5) are non-buyers and those identified in equation (4) are potential buyers.

The likelihood function under dependence can be expressed as:

$$\prod_{0}[1-\Pr(Y_i^* > 0, D_i > 0)] \times \prod_{+} \Pr(Y_i^* > 0, D_i > 0) \Pr(Y_i^* \mid Y_i^* > 0, D_i > 0) \quad (7)$$

With the dependent variable being purchase frequency, a Poisson distribution is appropriate. Correlation can be allowed between the two hurdles because the same person is controlling the two decision processes. Whether this correlation truly exists is subject to statistical testing. The parameter for the Poisson of the first hurdle is denoted as θ and that for the Poisson of the second hurdle is denoted as λ. Based on Holgate's bivariate Poisson distribution, the log-likelihood function is (Shonkwiler and Shaw, 1996)

$$LL = \sum_{0} \ln[\exp(-\lambda - \rho) + \exp(-\theta - \rho) - \exp(-\lambda - \theta - \rho)] +$$
$$\sum_{+} \ln[\frac{\exp(-\lambda - \rho)(\lambda + \rho)^Y}{Y!} - \frac{\exp(-\lambda - \theta - \rho)\lambda^Y}{Y!}] \quad (8)$$

Where ρ is the covariance parameter. With the logarithm link function: $\theta = \exp(Z\alpha)$ and $\lambda = \exp(X\beta)$, α, β and ρ can be estimated using maximum likelihood estimation.

The choice set in the question about the frequency of purchasing is classified into "1-2 times", "3-4 times", "5-6 times", "more than 6 times" and "did not purchase". Therefore, we use an interval censored specification in the second stage. Specifically, if the respondent chose "1-2 times", the probability is calculated as:

$\frac{\exp(-\lambda-\rho)(\lambda+\rho)}{1!}-\frac{\exp(-\lambda-\theta-\rho)\lambda}{1!}+\frac{\exp(-\lambda-\rho)(\lambda+\rho)^2}{2!}-\frac{\exp(-\lambda-\theta-\rho)\lambda^2}{2!}$. If the respondent chose "more than 6 times", the probability is:

$$1-(\exp(-\lambda-\rho)+\exp(-\theta-\rho)-\exp(-\lambda-\theta-\rho))-\sum_{Y=1}^{6}(\frac{\exp(-\lambda-\rho)(\lambda+\rho)^Y}{Y!}-\frac{\exp(-\lambda-\theta-\rho)\lambda^Y}{Y!})$$

After some simple derivation based on equation (8) (Shonkwiler and Shaw, 1996):

- The percentage of non-buyers is: $\exp(-\hat{\theta}-\hat{\rho})$.
- The percentage of potential buyers is: $(1-\exp(-\hat{\theta}))\times\exp(-\hat{\lambda}-\hat{\rho})$
- The percentage of buyers is: $1-\exp(-\hat{\lambda}-\hat{\rho})-\exp(-\hat{\theta}-\hat{\rho})+\exp(-\hat{\lambda}-\hat{\theta}-\hat{\rho})$

The Results

In the survey, 69.34% of the respondents are female. 82.81% are Caucasians, 11.45% are Blacks, 3.77% are Hispanics and 2.50% are Asians. The average household income is about $54,398 per year and the average age is about 46. 58.74% have four-year college degree or some college. 11.26% have post-graduate degree. 50.87% of the respondents are from southeast states and the rest are from northeast states of the U.S.

The estimation results are illustrated in Table 2. For fresh blueberries, income, awareness of the health benefits of blueberries, younger age and medium household size all have significant positive effects on the probability of participation (i.e., decision to purchase). People between 18 and 29 years of age and households of 3 or 4 people are more likely to decide to purchase fresh blueberries. Blacks are less likely to decide to purchase than other races. In the consumption stage (the second hurdle), Caucasians, Hispanics and Asians consume less than other races. Awareness of health

benefits is again significantly positive. Households of 5 people or more purchase more frequently than other household sizes and consumers in the northeast states purchase more than those in the southeast states.

For frozen blueberries, similar to fresh blueberries, awareness of the health benefits, younger age (18 to 44 year old) and bigger household size (5 people or above) all have significant positive effects on participation probability (the decision to purchase). However, income is not significant for the probability of purchasing frozen blueberries. The reason might be that frozen blueberries are less expensive than fresh ones, removing income as a barrier. Large households are also found to be more likely to purchase frozen blueberries, presumably because frozen blueberries are sold in large package size and are convenient to eat. In the consumption stage, only awareness of health benefits is significantly positive. None of the demographic information is found useful in explaining the quantity of frozen blueberry consumption. This is a reasonable result as frozen blueberries are cheaper and usually have larger package size. Therefore, we expect that there is no significant difference in the purchase quantity of frozen blueberries among frozen blueberry buyers. The demographics that affect the consumption of frozen blueberries mainly relate to whether people would be willing to buy frozen blueberries, not how much they would buy.

Our estimates show that knowledge of the health benefits of blueberries, family size and younger age are playing an important role in the consumption behavior for blueberries. The findings indicate that knowledge of the health benefits, which is significant in both stages for both blueberries, is promoting the consumption of blueberries. Additionally, younger people are becoming more and more mindful about

healthy food consumption. Households of more than 3 people are more likely to buy blueberries. Surprisingly, diet information and education level are insignificant in both stages for both types of blueberries.

For fresh blueberries, a seasonal effect is detected. The consumption volume is significantly smaller in December, January and February than in September. However, none of the month dummies is significant for frozen blueberries. This result is as expected since seasonality mainly affects fresh fruits. Thus, seasonality is an important factor that causes temporary reduced consumption in the fresh blueberry market. Further research on the impact of seasonality will be facilitated with the completion of the dataset to include the summer months.

The covariance estimate is not significant. Thus, our result is consistent with those of Schroeder et al. (2007), Blaylock and Blisard (1992), Burton, Tomlinson, and Young (1994) etc. in that no correlation between the participation decision and the consumption decision is detected. Therefore, promotion strategies that are effective in attracting new blueberry buyers may not be useful for increasing the blueberry consumption quantity of current blueberry buyers.

Consumer Structure

The estimated percentages of the three types of consumers in fresh and frozen blueberry markets are shown in Table 3. The result shows that for fresh blueberries, the proportion of blueberry buyers is around 47.37%, potential buyers is about 13.50% and non-buyers is about 39.13%. By contrast, for frozen blueberries, the proportions of buyers, potential buyers and non-buyers are 25.67%, 10.94% and 63.39% respectively. These figures reflect that in general, fresh blueberries are more attractive than frozen ones. Most respondents did not purchase frozen blueberries but almost half of them

purchased fresh blueberries during the period of data collection. The proportion of non-buyers for frozen blueberries is about 50 percent higher than the proportion of non-buyers for fresh blueberries. Therefore, blueberry consumption is dominated by the consumption of fresh ones. Fresh blueberries also possess a larger proportion of potential buyers.

Since non-buyers are people who do not pass the participation threshold and awareness of the health benefits of blueberries, age and household size are significant in the participation stages for both forms of blueberries, we conclude that older age, lack of knowledge about the health benefits of blueberries, or small household size (1-2 people) are among the characteristics that are generally shared by non-buyers.

Through the comparison of the consumer structures for the two blueberry forms, a far larger proportion of the population participate in the fresh blueberry market as opposed to the frozen blueberry market. While numerous factors (i.e., decrease in price or seasonal effect) can cause buyers to increase the purchase frequency for fresh blueberries, it's much harder for non-buyers to become buyers in the frozen blueberry market as demographic information is not easily changed. Therefore, the larger proportion of non-buyers affected by relatively stable reasons that keep them from participation might help explain the low increasing rate of frozen blueberry consumption since 1992.

Conclusion

This study contributes to the literature by conducting an in-depth analysis of the zero observations in consumption data. Namely, there are two categories of consumers with zero observations in the consumption stage: potential buyers and non-buyers. These two types of consumers are totally distinct in the consumption behavior, though

no difference is revealed by simply looking at the data. Being able to distinguish between these two types of consumers is critical to analyzing the growth potential of a market. It also helps the producers and retailers set up different marketing strategies targeting different types of consumers.

Our results show that the proportion of non-buyers of frozen blueberries is much larger than that of fresh blueberries. The reasons behind the non-participation of non-buyers for frozen blueberries are mostly stable demographic attributes. Income is only significant in the participation stage for fresh blueberries. Thus, economic reasons are part of the cause of the non-consumption of fresh blueberries while they are not the reasons for the non-consumption of frozen blueberries. The proportion of potential buyers for fresh blueberries is also larger than that for frozen blueberries. In addition, we find that seasonality is an important factor in the consumption stage for fresh blueberries. Lower prices during the high season may be the stimulant for the consumption of fresh fruits.

Our study is limited in several aspects. First, the purchase frequency information may not reflect the consumption amount accurately, even though blueberry is considered a highly perishable fruit. We use the frequency measure due to the difficulty in the collection of the non-uniform prices over the seasons and across the purchase locations. Second, the potential correlation between the consumption of fresh and frozen blueberries (i.e., substitution effect) is not considered. Future research could be conducted on a more precise measurement of fruit consumption amount and the substitution effects in fruit consumption.

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Table 1: List of Explanatory Dummy Variables and Explanation

Explanatory Variable	Explanation
diet_vegan	=1 if vegetarian or vegan; =0 otherwise
race_caucasian	=1 if Caucasian; =0 otherwise
race_black	=1 if Black or African American; =0 otherwise
race_hispanic	=1 if Hispanic; =0 otherwise
race_asian	=1 if Asian; =0 otherwise
male	=1 if male; =0 if female
educ_postgrad	=1 if education level is postgraduate; =0 otherwise
educ_college	=1 if education level is 4-year college degree or some college; =0 otherwise
awarehealth_yes	=1 if aware of the health benefits of blueberries; =0 otherwise
age18_29	=1 if of age between 18 and 29; =0 otherwise
age30_44	=1 if of age between 30 and 44; =0 otherwise
age45_59	=1 if of age between 45 and 59; =0 otherwise
people3_4	=1 if household has 3 or 4 people; =0 otherwise
people_5above	=1 if household has 5 people or above; =0 otherwise
northeast	=1 if living in northeast states of the U.S.; =0 if living in southeast states of the U.S.
oct, nov, dec, jan,feb	Month dummies

Note: Variables indicating other races, female, other education levels, age of 60 or above, household size of 1 or 2 people, southeast states and September are omitted for identification purpose.

Table 2: Double Hurdle Estimation Results

		Fresh Blueberry		Frozen Blueberry	
	Explanatory Variable	Coefficient	P-value	Coefficient	P-value
Participation Stage	diet_vegan	0.414	0.105	0.180	0.461
	income	0.003***	0.009	-0.000	0.927
	race_caucasian	-0.212	0.312	-0.016	0.950
	race_black	-0.466**	0.037	-0.235	0.399
	race_hispanic	-0.087	0.760	0.104	0.763
	race_asian	0.126	0.727	0.185	0.599
	male	0.016	0.857	0.049	0.675
	educ_postgrad	0.029	0.849	-0.008	0.968
	educ_college	0.033	0.735	-0.025	0.839
	Awarehealth_yes	0.699***	0.000	0.458***	0.000
	age18_29	0.617***	0.000	1.093***	0.000
	age30_44	0.217	0.107	0.668***	0.000
	age45_59	-0.022	0.854	0.232	0.187
	peop3_4	0.252**	0.014	0.221	0.074
	peop_5above	0.188	0.211	0.348**	0.046
	northeast	0.089	0.297	-0.148	0.174
	constant	-0.728**	0.014	-1.542***	0.000
Consumption Stage	diet_vegan	0.062	0.609	0.163	0.350
	income_con	-0.000	0.730	0.001	0.318
	race_caucasian	-0.433***	0.000	-0.407	0.058
	race_black	-0.111	0.401	-0.075	0.751
	race_hispanic	-0.394**	0.022	-0.379	0.167
	race_asian	-0.404**	0.024	-0.124	0.646
	male	0.101	0.105	0.105	0.254
	educ_postgrad	0.178	0.085	-0.119	0.467
	educ_college	0.040	0.559	-0.076	0.430
	Awarehealth_yes	0.168**	0.024	0.283***	0.006
	age18_29	0.151	0.105	0.197	0.214
	age30_44	0.048	0.617	0.186	0.250
	age45_59	0.031	0.730	-0.047	0.766
	peop3_4	0.080	0.234	-0.043	0.659
	peop_5above	0.210**	0.026	0.084	0.530
	northeast	0.135**	0.022	-0.004	0.961
	oct	-0.008	0.919	0.038	0.753
	nov	-0.081	0.319	0.008	0.952
	dec	-0.324***	0.001	-0.266	0.067
	jan	-0.248***	0.004	-0.196	0.162
	feb	-0.220**	0.013	-0.133	0.366
	constant	0.790***	0.000	0.534	0.076
Rho (Covariance Parameter)		-0.036	0.639	0.010	0.776
Model fit (P-value)		0.000		0.000	

Note: ** indicates significance at 5% level and *** indicates significance at 1% level.

Table 3: Consumer Structures for Fresh and Frozen Blueberry Markets

	Fresh Blueberry			Frozen Blueberry		
	Buyer	Potential buyer	Non-buyer	Buyer	Potential buyer	Non-buyer
Percentages	47.37%	13.50%	39.13%	25.67%	10.94%	63.39%

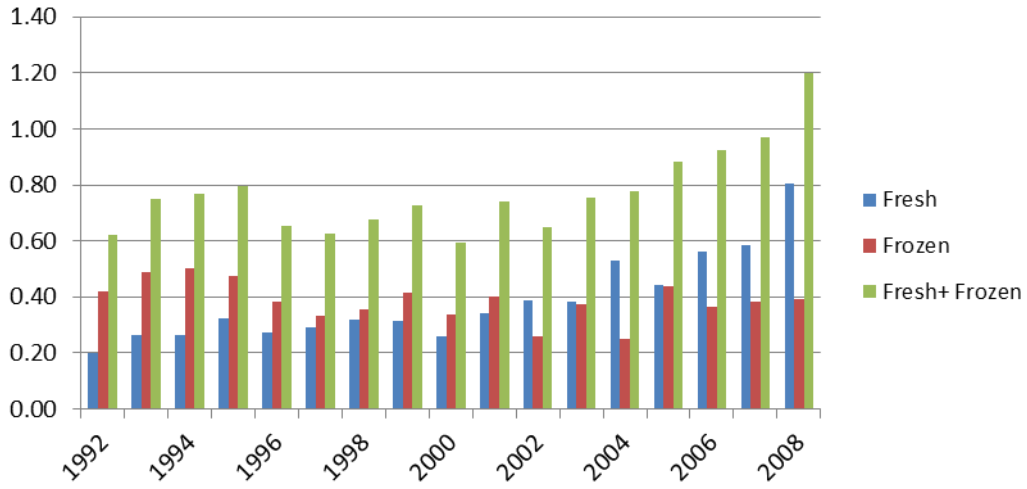

Figure 1: Per capita consumption of fresh and frozen blueberries from 1992 to 2008. (Unit: pounds) (Source: USDA, Economic Research Service Calculations)