THREE ESSAYS ON DIFFERENTIATED PRODUCTS AND HETEROGENEOUS CONSUMER PREFERENCES: THE CASE OF TABLE EGGS

by

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B.S., Henan University, 2008
M.S., North Dakota State University, 2011

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

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Abstract

Consumers' food demand has been found to be affected not only by prices and income, but also by their increasing concern about factors like health benefits, animal welfare, and environmental impacts. Thus, many food producers have differentiated and advertised their products using relevant attributes. The increasing demand and supply of differentiated food products have raised questions regarding consumer preferences and producer strategies. This dissertation consists of three essays and empirically examines the egg market to shed light on related issues.

The first question that this study aims to answer is whether consumers are willing to pay a premium for livestock and dairy products associated with improved animal welfare. Consumers' attitude towards such products not only affect manufacturers' production decisions, but also influence policy makers and current legislations. Using a national online survey with choice experiments, the first essay found that consumers in the study sample valued eggs produced under animal-friendly environment, suggesting incentives for producers to adopt animal welfare friendly practices.

In an actual shopping trip, consumers usually need to choose from products with multiple attributes and labels. Studying how consumers with heterogeneous preferences process these information simultaneously and make decisions is important for producers to target interested consumer segments and implement more effective labeling strategies. In the second essay, a different national online survey was administered. The analysis using a latent class model categorized the sample respondents into four classes, and their preferences toward attributes and various label combinations differed across classes.

Scanner data, which record actually purchased choices, are an important source of information to study consumer preferences. Diverging from the traditional demand approaches that are limited in studying differentiated product markets using scanner data, this study used a random coefficient logit model to overcome potential limitations and examine the demand relationship as well as price competition in the differentiated egg market. The third essay found that conventional and private labeled eggs yielded higher margins due to less elastic demand and cautioned producers of specialty eggs, which are usually sold at high prices despite their much more elastic demand.

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Major Professor
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Dedication

This dissertation is dedicated to my parents Heng Suting and Yan Mei.

Chapter 1 - Introduction

In the food markets, consumers' increasing concern about food safety, health benefits, animal welfare, and environmental impact has boosted the demand for differentiated agricultural products, such as organic, nutrient-enhanced, and animal-friendly varieties. To capture potential profit margins, producers have also been expanding their supply of these differentiated products. Through this increase in the demand and supply of differentiated products, several consumer research issues have emerged regarding producer's marketing strategies and consumers' heterogeneous preferences for specialty varieties. Labeling has become an important strategy for food manufacturers to directly communicate with consumers, as well as a useful tool for consumers to identify their preferred attributes. Knowing how consumer preferences are distributed within a market is essential for producers' decisions in many marketing activities, such as pricing, product designs, and target groups. Studies on these issues would improve our understanding about consumer behavior and producer strategies in the market. This dissertation consists of three essays on differentiated products and heterogeneous consumer preferences using the case of table eggs. The first study examines consumers' preferences and attitudes towards animal-welfare friendly products, the second study investigates the effects of multiple labels on consumers' choices, and the third study focuses on estimating the demand relationship of differentiated products using scanner data.

As the targeted industry in this dissertation, table eggs is a good example of differentiation in food markets. As a relative cheap source of protein and minerals for many consumers, the U.S. egg consumption has been stable in the past two decades (USDA, 2013). In recent years, people have become increasingly aware of particular attributes embodied in egg

products, and the sales of specialty eggs (e.g., certified organic) have been increasing steadily (Chang, Lusk, and Norwood, 2010; Brown, 2007; IBISWorld, 2014).

Animal-welfare friendly meat/dairy products have become a more popular differentiation because of worldwide concern and debate over farm animal welfare. Regarding the laying hens' welfare in the U.S., several related labels such as certified humane and cage-free have been developed by various organizations to indicate living conditions of laying hens. Moreover, state and local governments are also playing an active role to improve animal welfare. For example, California passed the Prevention of Farm Animal Cruelty Act that requires cages to be large enough for a hen to flap its wings without touching the side of the cage or another laying hen by 2015. Similar regulations are being debated in other states. IBISWorld (2014) reported that the sale of cage-free eggs accounted for 4.3% of the egg industry revenue in 2013.

In light of this current trend, the first essay of this dissertation examines consumers' perceptions and attitudes towards animal-welfare friendly egg products. Different from previous studies on this issue (e.g., Norwood and Lusk, 2011; Allender and Richards, 2010; Chang, Lusk, and Norwood, 2010), this paper focuses on two unaddressed questions: how consumers perceive and value various hens' welfare related managing practices; and how consumers respond to the trade-off between animal welfare and potential environmental impacts of these practices. A national online survey with a choice experiment was developed and administrated. Data were collected from 924 respondents representing the U.S. population. A random parameter logit model was applied to reveal consumer preferences and willingness-to-pay (WTP) accounting for consumer heterogeneity.

Consumers need information to make purchase decisions regarding differentiated products, and an effective way to communicate with consumers is labeling, particularly for

credence attribute (e.g., certified organic or cage-free). As labels continue to be an important strategy for manufactories, profusion of labels has raised questions about their effectiveness. The second essay is motivated by the increasing numbers and types of labels and the existence of redundant labeling of food products in the current market, where redundant labels are defined as those labels that do not provide additional information. The focus of this study is to understand how consumers value selected attribute labels jointly presented with other labels, including redundant labels, and examine interaction effects between labeled attributes. If certain attribute combinations are subject to interaction effects, are these effects substitutes or complements for consumer's valuation? Data were collected by an online survey nationwide. The choice experiment based responses were analyzed using a latent class model, which categorized respondents into four classes based on their preferences. The WTP accounting for interaction terms were also calculated to identify the most valued product in each class.

To study consumers' preferences and demand for agricultural products, stated and revealed preference data are two data sources widely applied in the literature. Revealed preference data, such as scanner data, have become popular because they reflect consumers' real purchased choices. As essay 1 and essay 2 used stated preferences through hypothetical choice experiment, scanner data are used in the third essay to estimate demand relationship for differentiated eggs. The dataset recorded egg sales nationwide from 2008 to 2010, including over 300 brands with 2,287 egg products that are differentiated by size, package size, shell color, and labeled attributes. The data were used to estimate a BLP random coefficient logit model (Berry, Lavinsohn, and Pakes, 1995; henceforth BLP), which claims to overcome the dimensionality issue of applying traditional demand models to scanner data and allows for consumer heterogeneity. The BLP model has few applications in the agricultural marketing literature to

date, majorly due to its complex computation (Lopez and Lopez, 2009; Richards, Acharya, and Molina, 2011). Besides the own- and cross-price elasticities, the profit margin and marginal costs at product level were calculated from estimated parameters. Such studies would help improving our understanding of price competition of differentiated products in the market.

In this dissertation, Essays 1 through 3 are presented in Chapters 2 through 4, respectively. Essay 1 has been published in volume 38, issue 3 of *Journal of Agricultural and Resource Economics*. In Chapter 5, I summarize the key findings and contributions from the three essays.

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Chapter 2 - Consumer Attitudes toward Farm Animal Welfare: the Case of Eggs

Introduction

Producers of animal-based foods, consumers, and policy makers around the world have become increasingly mindful of farm animal welfare in recent years. European laws since the 1960s have recognized that farm animals can feel, experience, and suffer, and they serve as the basis for many animal welfare standards in a number of countries. Increasing awareness of farm animal welfare in the United States also has led to changes in state regulations and industry standards. For example, gestation crates are now banned in Florida and Arizona (International Finance Corporation, 2006; Lusk, Norwood, and Prickeet, 2007). In 2002, the United Egg Producers (UEP), representing nearly 90% of U.S. egg producers, launched the UEP Certified Program, which requires increasing stocking space for laying hens from 48 to 67-86 square inches per bird. By 2010, 80% of all eggs in the U.S. were produced under the guideline (United Egg Producers, 2010).

Concerns over laying hens' welfare have been widely debated in the United States, not unlike in Europe, where laying hens were identified as needing the most improvement in welfare among farm animals (European Commission, 2005). Several animal welfare-related labels such as *certified humane* and *cage-free* have been developed by various groups to indicate the living conditions of laying hens. The label "Animal Welfare Approved" developed by the Animal Welfare Institute, for example, requires cage-free conditions and outdoor access for laying hens to perform their natural behaviors, including nesting, perching, and dust bathing, and forbids forced molting and beak cutting (The Human Society of the United States, 2011). Many universities and restaurants, including Starbucks and Burger King, now request eggs produced

from layer-friendly systems (The Human Society of the United States, 2011), and consumers appear to be willing to pay some premium for these welfare-related labels (Sumner *et al.*, 2011).

State and local governments also are playing an active role in improving laying hens' well-being. In 2008, California passed the Prevention of Farm Animal Cruelty Act, which requires the cage to be large enough for a hen to stand up, turn around, and flap its wings without touching the side of the cage or another laying hen by 2015. Michigan passed a similar law in 2009 to forbid battery cages. Similar regulations are being debated in other states, including Ohio and Oregon. The new regulations could increase the production costs of eggs and considerably reduce the number of eggs produced within the state and increase egg shipments from other states (Sumner *et al*., 2010). These regulations could also have potential environmental impacts. Recent studies have found that cage-free systems could generate more air and water pollution and use more energy than traditional cage systems (Xin *et al*., 2011; Thompson *et al*., 2011). In order to accurately predict the effects of higher welfare standards on marketing opportunities for egg producers, we first need to understand consumers' knowledge and perceptions of hen welfare and how they might react to the likely tradeoff between hen welfare and environmental consequences.

The objective of this study was threefold: to determine the state of consumers' perceptions and knowledge about welfare issues pertaining to laying hens, to assess how consumers value various practices of managing laying hens that are related to hens' welfare, and to examine how consumers respond to new knowledge regarding potential environmental impacts of these practices. To address the study objectives, an online survey was developed and administered nationwide. The choice experiment responses were collected for eggs produced

from layers under different management practices and analyzed using a random parameter logit model accounting for the information effect and heterogeneity in consumer attitudes.

We proceed with a review of the related literature, present the survey instrument and the model used, and discuss the results. Our findings provide practical implications for U.S. egg producers and a more complete picture of consumer preferences about eggs. Respondents generally regarded the basic living needs of hens as the most important factor in layers' welfare. Over half of them perceived management practices such as induced molting, caged housing, and beaks trimming as reductions of the birds' welfare. Our estimates suggest that the majority of consumers are willing to pay an average premium of $0.21 to $0.49 per dozen for eggs produced in a cage-free environment with outdoor access or without induced molting. The results also indicate that consumers currently place more weight on animal welfare issues than potential environmental issues in their selection of animal-based food products.

Literature Review

U.S. egg consumption declined in post-World War II decades through the early 1990s, reflecting consumers' concerns regarding cholesterol and salmonella. The decline also might have been caused by lifestyle changes that led to more food being consumed away from home (Brown and Schrader, 1990). Lately, eggs have been marketed as a healthy food product and a relatively cheap source of protein and minerals, which has stabilized egg consumption (Thompson *et al*., 2011); U.S. consumers spend approximate $14.2 billion annually on eggs (USDA-FSIS, 2005).

Reflecting the general trends in foods, the U.S. egg market has become highly differentiated in recent years. Sales of specialty eggs that are differentiated from conventional eggs by nutrient content or circumstance of raising hens, have increased steadily and accounted

for nearly 16% of the entire egg market in 2005 (Chang, Lusk, and Norwood, 2010; Brown, 2007). Organic egg sales, in particular, have grown rapidly at an average annual rate of 19% from 2000 to 2005 (Oberholtzer, Greene, and Lopez, 2006; USDA-FSIS, 2005). Researchers have begun to investigate consumer preferences for differentiated eggs. Andersen (2011) found that people were willing to pay a higher premium for organic eggs, which was attributed to consumers perceiving organic eggs as healthier food and being more familiar with the "organic" label. Canadian consumers were shown to be willing to pay a premium for Omega-3 eggs (Asselin, 2005). Baltzer (2004), using scanner data on weekly sales of eggs, found Danish consumers were willing to pay a significant premium for organic production methods and improvements in animal welfare.

With increasing concerns about animal welfare, the "cage-free" designation has become one of the attributes commonly associated with hens' welfare. In the United States, the majority of laying hens are confined in cages with limited space for each bird. These conventional housing systems have been criticized by animal advocacy groups because hens cannot extend their wings and are unable to exhibit natural behaviors such as nesting and dust bathing (The Human Society of the United States, 2011). Several studies have been conducted to assess consumers' attitudes toward animal welfare and demand for related products. Fearne and Lavell (1996) found that price and animal welfare were valued as two key attributes of egg consumption by consumers in the UK. Norwood and Lusk (2011) found that people highly valued cage-free systems and were willing to pay a $0.95 premium for a dozen eggs raised in a cage-free system rather than a traditional caged system. On the other hand, Allender and Richards (2010) found only about 20% of households were willing to buy cage-free eggs at average 2007-2008 prices. Another study found that although people were willing to pay a significant premium on average

for cage-free eggs, nearly half of the typically observed premium was attributed to egg color rather than better living conditions of hens (Chang, Lusk, and Norwood, 2010). While such inconsistent findings may be attributed to different methods, the investigation on whether consumers are willing to pay extra for eggs produced from non-conventional systems is far from over.

Several important questions on animal welfare remain unanswered. One such question pertains to consumers' general attitudes toward animal welfare. The concept of animal welfare is complex, and many factors should be considered in assessing animal welfare. People likely have different perceptions of these factors. For example, conventional housing systems that confine hens in cages provide clean shelters and comfortable temperatures for birds and help keep production costs low. Hens' beaks are often trimmed to prevent them from pecking and harming other birds. Although these management practices protect hens in some respects, they usually have been viewed as reductions of animal welfare by the public, because cutting beaks appears brutal and caged hens cannot access the outdoors and have no freedom to nest, perch, or even spread their wings. According to Lusk, Norwood, and Prickeet (2007), people value the opportunity for farm animals to exhibit natural behaviors and exercise outdoors more than protection from other animals and comfortable shelter; thus, one goal of our study was to identify what practices are perceived by consumers to impact welfare of layer hens.

Another question of interest relates to recent studies revealing the environmental costs of cage-free and outdoor access systems. Cage-free systems or other systems allowing outdoor access was reported to generate more air and water pollution, thus placing a heavier burden on the environment than traditional caged housing systems (Xin *et al*., 2011). Thompson *et al.* (2011) concluded that although hen manure is a valuable nutrient resource for crops, its handling

can produce significant environmental damage to air and water quality. Moreover, housing systems without cages use 15% more feed and energy to maintain optimal temperatures for layers due to lower stocking densities (Williams, Audsley, and Sanders, 2006). Such tradeoff between animal welfare enhancement and environmental degradation is likely an issue most consumers have not yet considered with conceivable impacts on how they value animal welfare. This study evaluated how environmental concerns may influence consumers' valuation of layer management practices.

Survey Design

The survey instrument was designed to address the study objectives, consisting of the cover letter, screening questions, general questions, choice scenarios, and demographic questions. To ensure respondents did not self-select based on their views or interest in animal welfare issues, the cover letter of the survey mentioned the content of the survey as pertaining to consumption of chicken eggs, with no mention of animal welfare until several questions into the survey. The screening questions aimed to restrict our sample to experienced egg shoppers. The general questions gathered information on shopping behavior and perceptions of animal welfare as well as knowledge about environmental impacts of layer management. The demographic information, including gender, age, education, household annual income, and geographic areas of residence, were collected at the end of survey.

The choice experiment was designed to estimate marginal values of several attributes of a dozen eggs, including price ($1.99, $2.49, $2.99), shell color (white or brown), feed types (conventional, vegetarian, organic), and four animal welfare-related attributes (outdoor access, confined in cages, stocking density, and induced molting). The levels of each attribute are summarized in Table 2.1. The lowest level of price was set at the national average retail prices of

regular brown eggs (Grade A, large) during the week of March 9, 2012 (USDA-AMS, 2012). The middle level and highest level of prices were about 25% and 50% higher than the lowest price level, respectively. The three levels of stocking density were set at 67 square inches, 138 square inches, and 1.5 square feet (216 square inches) per bird, where the highest density was chosen based on the UEP standards, the medium density was the average space for hens to fully stretch their wings (Dawkins and Hardie, 1989), and the lowest density followed third-party authorized animal welfare standards, such as Certified Humane and Animal Welfare Approved (Animal Welfare Approved, 2011).

A full factorial design included 432 (=3×2×3×2×2×2×3) product profiles. After deleting two extreme profiles (i.e., the combination of practices that appear to be stereotypically perceived as superior for hens' welfare [no cage with outdoor access and low stocking density and organic feed associated with the lowest price], and the combination of practices with perceived lowest welfare conditions and conventional feed associated with the highest price), a macro in SAS 9.1 suggested 54 profiles for a fractional factorial design, which yielded a D-efficiency score over 99%. The profiles were grouped into 18 choice scenarios with three products each, which were blocked into three sets of six choice scenarios to minimize response fatigue. For each scenario, respondents were asked to choose from three products with different attributes and a "Not buy any of the three" option. Each egg product was pictured in a generic, dozen-case, paper carton in color to convey the shell color.

To examine the effects of the possible environmental consequences on consumers' valuation, the survey was administered in two versions, with and without additional information on environmental aspects of non-cage systems and provision of outdoor access to layer hens. To make the statement objective, potential environmental burdens of both non-caged and caged

systems were explained. The full statement found in the Appendix was presented to a subset of the respondents prior to the choice scenarios. We hypothesized that respondents with additional information would become more conflicted about management practices and may value these attributes lower than respondents without additional information. Because the statement mentions that there are environmental costs associated with all types of systems, it is also possible that respondents may have increased their valuation premium on welfare-enhancing practices, if they believed a priori that the environmental costs might be larger for those systems.

The Model

Stated preference methods are based on the theory of utility maximization. When they are presented with a choice task, respondents are assumed to choose the alternative with the combination of attributes that would provide them the highest level of utility. When consumers choose among egg products with similar attributes, their preferences for various attributes are expected to be correlated, and thus the Independence of Irrelevant Alternatives assumption of the multinomial logit model is violated. A random parameters logit (RPL) model was used in this study to overcome the multinomial logit model limitation and to examine the heterogeneity of preferences within the population (Hensher and Greene, 2001; McFadden and Train, 2000).

The utility of an individual *i* derived from choosing alternative *j* can be written as:

$$U_{ij} = \beta_i X_{ij} + \varepsilon_{ij} \tag{2.1}$$

where X_{ij} is a vector of observed variables consisting of attributes of the alternatives and individual characteristics. The parameter vector β_i varies across individuals with density $f(\beta|\theta)$, where θ is the parameter vector that defines this distribution and ε_{ij} represents the unobservable, random term assumed to be an independent and identically distributed (iid) extreme value.

Following Hensher and Greene (2001), the choice probabilities are integrals of standard logit probabilities over the parameter densities and can be written as:

$$P_{ij}(\theta) = \int (\frac{e^{X_{ij}\beta_i}}{\sum_{k=0}^{J} e^{X_{ik}\beta_i}}) f(\beta|\theta) d\beta \tag{2.2}$$

The individual's utility was specified for choosing one of three egg products or "none of these three" option with price, product attribute variables, and informational interaction terms, and it can be written as:

$$U_{ij} = \beta_{0ij} + \beta_{1i}Price_j + \beta_{2i}Color_j + \beta_{3i}Organic_j + \beta_{4i}Vegetarian_j + \beta_{5i}Access_j + \beta_{6i}Cagefree_j + \beta_{7i}Density_j + \beta_{8i}NoMolting_j + \varepsilon_{ij} \tag{2.3}$$

where *Color, Organic, Vegetarian, Access, Cagefree,* and *NoMolting* are dummy variables representing egg product attributes, with the value of 1 indicating their presence. The *Density* variable assumed the values of stocking density in the experiment measured in 10 squared inches. Because this was not a branded design, a single intercept was specified for all egg products. The utility function was normalized by setting the value for the opt-out option at 0.

The conditional means of selected parameters were modeled as functions of individual characteristics, including whether the individuals were exposed to additional information about the environmental consequences of layer management practices. That is:

$$\beta_{ki} = \beta_k + \delta_k' z_i + \gamma_k I_i + \sigma_k v_i, \tag{2.4}$$

where β_k is the population mean for the *k*th coefficient, δ, γ, and σ are parameters, z_i is a vector of observed individual characteristics, I_i is an indicator of whether the individual received additional information, and v_i is an iid error term. The parameter γ_k will measure the effect of information on an individual's valuation of egg attributes. Willingness-to-pay for the *k*th attribute by individual *i* (WTP_{ki}) can be estimated as the negative ratio between the attribute and

price parameters; the attribute parameter is individual-specific (β_{ki}) while the price parameter (β_1) is fixed across individuals:

$$WTP_{ki} = -\frac{\beta_{ki}}{\beta_1} \ . \tag{2.5}$$

Results

The survey was administered online in March of 2012, several weeks before Easter. A nationwide representative sample was provided by Research Now, stratified by age, gender, region, ethnicity, and household income. The survey was pre-tested with 60 respondents to ensure clarity of questions and balanced response across attribute levels for statistical reliance. Based on the pretest results in which a large portion of the respondents chose the two lower price levels, the price intervals between the three price levels were reduced from an initial range of $0.80 to $0.50. The actual launch returned a sample of 1,049 responses. Of these, a total of 924 responses that were completed in more than seven minutes were used for analysis, with 449 completing the version without information on environmental aspects (version 1) and 475 completing the version with information (version 2).[1]

Sample Characteristics

The demographic profile of the sample is compared to the national statistics in Table 2.2. The respondent demographics were mostly comparable to those of the population, although our

[1] Seven minutes was specified as a cutoff, because we expected an average respondent to take about 15 minutes to complete the survey while some quicker readers may spend less time. Of the total completions, the average time was 23 minutes, with the most number of responses completed between 10 and 15 minutes.

survey sample had higher proportions of females and individuals with bachelor's degrees or higher. Because respondents were screened to ensure that they were responsible for at least half of the household grocery shopping, it was not surprising to receive more responses from women. The educational attainment of the survey sample may be reflective of the fact that people with higher education have more interest in taking research surveys and expressing their views about animal welfare. In interpreting the results, we need to consider the impact of our sample consisting of relatively more individuals with higher educational attainment. T-tests were conducted to find that there were no statistical differences in demographics of respondents between the two versions.

Perceptions and Knowledge about Farm Animal Welfare

The respondents were asked to rank seven items related to farm animal treatment in the order of importance (Table 2.3). The items are listed in the order of the average ranking, where ranking 7 corresponded to most important and 1 to least important. The results showed the respondents' views were much more divided for the items "Receive fresh and clean food and water" and "Are raised in ways to keep our food costs low" compared to the other items. These two items were ranked the highest and lowest according to the average ranking by being considered most important by the largest percentages of respondents (38.5% and 23.7%, respectively) and least important, also by the largest percentages of respondents (25.1% and 33.2%, respectively).

The views toward other items were more moderate in terms of the percentages of respondents ranking them as the most and least important. The items receiving the third and fourth largest percentages of the first ranking were "Receive treatment for injury and disease" and "Are allowed to exhibit natural behaviors," each from about 8% of the respondents. But, the

item “Are allowed to exhibit natural behaviors” received the lowest ranking in importance from 11.8% of the respondents, resulting in the second lowest average ranking.

Different sets of questions soliciting responses using a Likert-type 5-point scale probed respondents’ perceptions of products produced in an animal-friendly environment and the impact of conventional management practices on hens’ welfare. As shown in Table 2.4, more than 75% of respondents somewhat or completely agreed that food products from an animal-friendly environment are from happier and healthier farm animals, are healthier for humans, and are of better quality. About 65% somewhat or completely agreed that these products are better for the environment, whereas nearly 60% of the respondents believed that these products taste better.

As expected, individuals perceived differently about how various farming practices may affect the welfare of hens. Average scores suggest that housing hens in cages and trimming beaks were perceived as having slightly negative effects on hens’ welfare. Yet, the responses were divided. For example, half of the respondents believed that housing hens in cages would somewhat or definitely worsen their welfare, while 22% believed that the practice would somewhat or definitely improve their welfare. The opinions on induced molting were more unified with over 62% believing that induced molting would somewhat or definitely worsen hens’ welfare.

To gauge the level of knowledge about the environmental impacts of management practices, the respondents were asked to evaluate several statements (Table 2.5). Over 40% of respondents were neutral with respect to those questions, which likely indicates that they were relatively uninformed. A greater percentage of respondents incorrectly believed that a management practice that contributes to a higher level of hen welfare also places a lower burden on environment. Approximately 50% of respondents were indifferent with respect to the tradeoff

between animal welfare and environmental degradation. These responses provide a basis for understanding the information effects.

Model Parameter Estimates

In equation (2.3), the intercept and the price coefficient was specified as fixed across individuals to simplify the computation of implicit values following convention[2]. All other parameters were specified as random with normal distribution. In addition, the means of the coefficients on the attributes of welfare-related management practices (*Access*, *Cagefree*, *Density*, and *NoMolting*) were specified as functions of individual characteristics. The selected respondent characteristics in equation (2.4) included gender (a binary variable *Fem* equaling one for female), age (*Age*), household income (*Income*), educational attainment (a binary variable *BPlus* of 1 for a bachelor's degree or higher), exposure to the additional statement regarding environmental impacts, and the respondent's attitudes towards hens' welfare.

Definitions and descriptive statistics of the variables in the analysis are reported in Table 2.6. The *Age* variable assumed the midpoint in each age range; i.e., a response of 25–34 was given a value of 30, and the *Income* variable assumed the midpoint in each income range measured in $10,000. Attitudes were measured by 11 items measured on similar scales, as discussed above. A varimax rotation of an initial factor analysis of those 11 items identified three

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[2] Identification of parameters in the random parameter logit models can be difficult in practice, and the model may not converge in a reasonable number of iterations (Revelt and Train, 1998; Train and Weeks, 2005). Fixing the price coefficient facilitates a straightforward interpretation of the model, allowing for the WTP for each attribute to be distributed in the same way as the attribute's coefficient.

factors, and a Chronbach's α test was conducted to test the reliability and acceptability of each factor (Cortina, 1993). As a result, two factors with values of α greater than 0.70 were usable. The first factor represented the respondents' perceptions on quality of products produced in an animal friendly environment, and the second measured their perceived impacts of management practices on hens' welfare (Table 2.4). Responses to questions grouped under each factor were averaged respectively to generate two attitudinal variables that are measured on a scale between 1 and 5. Higher values for *PQTY* correspond to more favorable perceptions toward animal friendly products. Higher values for *PMNT* relate to more strongly held perceptions that common management practices negatively affect animal welfare. Lastly, a binary variable *INFO* was specified to equal 1 for versions with the additional statement found in the Appendix.

The random parameter logit model was estimated by maximum simulated likelihood using 100 Halton draws using NLOGIT 4.0 (Greene, 2007). The estimates of the mean and standard deviations of the structural parameter densities are presented in Table 2.7. As expected, the intercept is positive, suggesting that egg purchases generate utility, and the coefficient for *Price* was negative and statistically significant, indicating that respondents obtain disutility from higher prices. The coefficients for *Color*, *Organic*, and *Vegetarian* were mostly statistically significant at the 1% level, with small means and large standard deviations that were nearly three- to ten-fold in magnitude, suggesting wide variations in preferences for shell color and feed type. On average, respondents preferred white eggs and eggs from hens raised with organic feed, conventional feed, and vegetarian feed, in that order.

As for the welfare-related attributes, the means for *Access*, *Cagefree*, and *NoMolting* were statistically not different from zero, but their standard deviations were similar to those for shell color and feed type. The exception was stocking density (*Density*), where the mean

coefficient for giving each hen an additional 10 square feet was twice as much as its standard deviation, suggesting relatively unified preferences for lower stocking density.[3]

The heterogeneity-in-mean parameters capture the effects of demographic, attitudinal, and informational variables on attribute parameters. Their estimated values indicated that female respondents valued non-induced molting more than male respondents, whereas male respondents placed higher values on lower stocking density and outdoor access than female respondents. Younger respondents, on average, valued lower stocking density more than older respondents. Income levels or educational attainment did not explain systematic differences in preferences toward the attributes associated with management practices considered in the study.

Attitudes toward animal welfare helped explain some variation in how respondents valued management practices associated with hens' welfare. Respondents with favorable perceptions of pro-animal welfare products (*PQTY*) placed higher values on the outdoor access and cage-free attributes than their counterparts. These estimates suggest that these respondents on average regard cage-free and outdoor access as more important factors influencing the quality of eggs than adjusting stocking density or not inducing molting. Respondents with perceptions that common management practices negatively affect animal welfare (*PMNT*) valued the cage-free and no-induced-molting attributes more highly and lower density less than others, suggesting that these consumers likely perceive caged housing and induced molting as critical violations of animal welfare. The dismissal of stocking density as a valuable practice to enhance welfare diverges from the *PQTY* findings.

[3] Note: higher values for *Density* indicate more space per bird, or lower stocking density.

The provision of information affected the valuations of outdoor access and stocking density. Respondents who were given information on the environmental impacts valued outdoor access and lower stocking density higher on average than those without the information. The statement might not have changed the minds of those who had formed their opinions toward animal welfare issues; rather, the statement, which laid out environmental concerns for all management practices, might have emboldened consumers who already favored these attributes to state higher values.

Willingness-to-Pay Estimates

Individual WTP estimates for all attributes were simulated according to equation (2.5). In the interest of space, we report the results for shell color and feed type for the full sample and for the attributes associated with management practices in a few different groupings in Table 2.8. One grouping further explores the impact of the environmental information, and the other groupings examine the WTP values by respondents' perceptions on the quality of products from an animal-friendly environment and the impacts of management practices on hens' welfare.

At the top of Table 2.8, statistics of individual-specific WTPs for shell color and feed types (organic and vegetarian) are reported for the entire sample. We found that the average WTP for brown eggs over white was negative (18 cents per dozen), with 29% of the respondents willing to pay a premium. This result is different from some previous studies; for example, Fearne and Lavell (1996) reported that consumers preferred brown eggs to white ones in the UK, and Chang, Lusk, and Norwood (2010) found consumers were willing to pay an extra $0.73 for brown eggs. One explanation for the differing results may be that more consumers realizing that the difference of colors is due to different breed and does not represent higher nutrition or better quality, which was stated for respondents before choice experiments. Also, because brown shells

are commonly associated with organic-fed or cage-free eggs in marketing, the premium for brown eggs in earlier studies may result from these attributes. As Chang, Lusk, and Norwood (2010) suggested, analyses using data from retailers may indicate a higher premium for brown eggs than those estimated from our survey responses by not controlling for the organic-fed or cage-free attributes.

Regarding feed type, average respondents were willing to pay a more than $0.10 in premium for organic-fed eggs and willing to accept a $0.05 discount for vegetarian-fed eggs over conventional eggs. Approximately 72% and 41% of respondents were willing to pay a premium for organic and vegetarian-fed eggs over conventional eggs, respectively. This result is consistent with previous studies indicating organic eggs were generally perceived as healthier (Baltzer, 2004; Anderson, 2009). The standard deviations and ranges of the estimated WTPs suggest much heterogeneity in preferences on the color and feed type attributes.

The WTP statistics for the welfare-related management practices are first reported by whether the individuals received additional information. Changes in the WTP distribution for outdoor access and lower stocking density between the informed and uninformed groups were similar, suggesting that environmental concerns could boost respondents' WTP for providing outdoor access or additional space for hens. Among those who received additional information, 89% (59%) of the respondents were willing to pay a premium for eggs from hens given outdoor access (more space), with a mean premium of $0.25. In the sub-sample that did not receive the additional information, the mean premium for outdoor access (more space) was lower at $0.16, with 81% (43%) of those willing to pay a premium. The average WTPs for lower stocking density were small in magnitude, but it was positive for the informed group and negative for the uninformed group. Irrespective of the information effect, the highest amount an individual was

willing to pay for eggs from hens given 138 square inches each compared to the basic UEP standards of 67 square inches per bird was about $0.35 to $0.42 and another $0.40 to $0.48 for further lowering the density to provide 1.5 square feet per bird.

Information on the environmental consequences seemingly shifted the WTP distributions for these attributes to the right, because there was little change in standard deviation and range between the two groups. We tested the similarities in demographics between the two groups and the similarities in attitudes towards animal welfare using the *PQTY* and *PMNT* factors. The t-tests showed no significant differences in *PQTY* and *PMNT* between the two groups ($p < 0.0001$ for both). Thus, we confidently attribute the shift to the information effect.

Few differences are noted between the two sub-samples for the WTP for the cage-free attribute, except that average WTP was slightly higher among the uninformed group ($0.50 versus $0.47). Regardless of receiving the additional information, about 93% of respondents were willing to pay a premium for it. This result is supported by other studies that found the majority of consumers preferred cage-free eggs over conventional eggs (Fearne and Lavell, 1996; Norwood and Lusk, 2011). Moreover, the average premium of cage-free was the highest among the attributes considered, which reflect consumers' familiarity with cage-free eggs. In our sample, nearly 70% of the respondents stated they were somewhat or very familiar with the cage-free label; the American Egg Board reported in 2010 that only about 30% of consumers were familiar with this attribute (American Egg Board, 2010). Perhaps the familiarity contributed to a preconceived valuation of the attribute, thus yielding a negligible information effect.

More than 95% of respondents were willing to pay a premium for eggs from hens that were not forced into molting. The only notable effect of information on the WTP was a decrease in average WTP from $0.40 among the uninformed to $0.35 among the informed. This result is

slightly surprising, because the environmental statement did not directly pertain to molting practices.

The bottom half of Table 2.8 reports WTP statistics by respondents with favorable perceptions of animal welfare-friendly products (*PQTY* > 3) and their counterparts (*PQTY* ≤ 3), as well as by respondents who perceive that common management practices would reduce animal welfare (*PMNT* > 3) and those who do not (*PMNT* ≤ 3). Although the differences in means between the sub-samples are not statistically significant, several trends emerge from the results.

How people perceive the quality of animal welfare-friendly products seems to systematically influence their valuations of egg attributes associated with management practices. In particular, those who have higher opinions of animal welfare-friendly products were willing to pay more than their counterparts for giving hens outdoor access and not keeping them in battery cages but less for additional space per bird. Among the former group, more respondents were willing to pay a premium for outdoor access (86% versus 81%) and fewer respondents were will to pay a premium for additional stocking space (50% versus 60%).

Regarding induced molting, few differences are seen in the WTP distributions because of perceived differences in product quality, but the difference in the average WTP between those who perceived the harm of animal welfare from common management practices and their counterparts was notable. Specifically, those who believed that common management practices had negative impacts on hens' welfare (*PMNT* > 3) were willing to pay on average $0.45 per dozen for eggs from hens that were not subjected to induced molting compared with $0.24 among those who were not as concerned. The percentage of respondents willing to pay a positive premium was 98% among the concerned compared with 87% among those not as concerned. The

perceived impacts of management practices had minimal effects on the WTP distributions for hens with outdoor access and cage-free hens, although the average WTP for cage-free hens was $0.06 per dozen lower among those not as concerned. Those with negative perceptions of management practices were willing to pay less on average for additional space for each hen, which is slightly counterintuitive. Consumers may not value space as much as the other more tangible attributes. Alternatively, concerned consumers also may be sufficiently informed to know that hens prefer to flock together; that is, small space will not hurt them as long as they are let out of cages and/or granted outdoor access.

Conclusion

This study examined consumer attitudes and preferences regarding farm animal welfare in the case of layer hens. Among factors affecting hens' welfare, the views were divided on the importance of the basic needs of "receiving fresh and clean food and water" and the need to have animals "raised in ways to keep lower costs" than toward other factors that could be considered to enhance the welfare of layer hens. Food cost remains one of the most important factors for over a third of the respondents, suggesting providing eggs at a low price is critical for producers.

That said, the majority of respondents (63.5%) perceived that conventional layer management practices of housing hens in cages, beak trimming, and induced molting worsen hens' welfare. A greater majority (86%) held favorable impressions about the quality of products produced in animal-friendly environment. Indeed, our analysis found over 85% were willing to pay a premium to improve hens' welfare attributes, including outdoor access, cage-free housing, and non-induced molting. Of the attributes considered, the cage-free attribute was preferred with the highest average premium of $0.49 per dozen, which exceeded the estimated increase in cost of $0.40 per dozen from caged systems to cage-free systems (Sumner *et al*.,

2010), indicating a potentially profitable opportunity for producers to switch. If the other management practices (i.e., providing outdoor access or relying only on natural molting) are not as costly as the estimated premia, producers could be better off if they incorporate these practices. Suitably designed educational campaigns could encourage consumers to seek out products from animal welfare-friendly practices and provide incentives for producers to take advantage of such demand. Consumers also were willing to pay $0.10 per dozen extra for organic-fed eggs relative to conventional eggs. Although organic eggs account for a relatively small share of the market, our results indicate that respondents clearly preferred them and were willing to pay extra for these eggs.

The estimated impact of additional information on the environmental aspect of layer management practices suggests that environmental impact is an issue that consumers would consider when purchasing animal-based food. When provided the information that different housing systems could cause environmental problems, the distributions of the willingness-to-pay for providing outdoor access and more space to hens shifted in a positive direction. Consumer preferences will likely evolve as scientists reveal more definitive findings on the environmental costs associated with each management practice. As of now, their valuations of welfare-related attributes likely trump their concerns for any environmental consequences.

Designing a management system that maximizes farm animal welfare is complex. Although the cage-free system has some negative implications for hens' welfare and the caged system has some managerial advantages, consumer preferences for cage-free eggs appear to be strong and irreversible for the near future. Our value estimates are subject to potential hypothetical bias inherent in the stated preference methods, but are consistent with the respondents' attitudes towards animal welfare. Our model also did not account for other factors

that may systematically impact egg preferences, including ethnicity. For example, our sample underrepresented Hispanic respondents (4.9% compared to 16.9% in the US population). Further research is needed to quantify any WTP differentials across ethnic groups. As various regulations are legislated and debated at the state level, our findings suggest that consumer preferences for hens' welfare would have an impact on intrastate flow of eggs. Such an impact could be large if many consumers value animal welfare concerns more than consuming locally produced foods.

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Appendix - Additional Statement That Appeared in Version 2 of Survey Instrument

Housing Systems and Environmental Impacts:

Cage-free systems and other housing systems that allow for outdoor access in egg production provide hens with more freedom to move. Lower stocking density (i.e., fewer birds per unit of space) allows hens to exhibit their natural behaviors. Some scientific studies have found that these systems generally contribute to poorer air quality with higher emission levels of ammonia and dust than conventional housing systems. Moreover, these systems require more feed and energy to maintain optimal temperatures. Thus, cage-free and other housing systems that allow for outdoor access likely contribute to larger environmental footprints with greater resource utilization. At the same time, some other studies indicate that traditional housing systems with higher stocking density generate higher levels of environmental degradation, particularly pertaining to waste-related pollution.

Table 2.1. Attributes of the Choice Experiment[a]

Attributes	Levels
Price	$1.99, $2.49, $2.99
Color of Shell	Brown (*Color*), White
Feed Type	Organic (*Organic*), Vegetarian (*Vegetarian*), Conventional
Induced Molting	Not induced (*NoMolting*), Induced
Use of Cage	Cage-free (*Cagefree*), Caged
Outdoor Access	Yes (*Access*), None
Stocking Density (*Density*[b])	67 sq. inches, 138 sq. inches, 216 sq. inches

[a] The italicized terms are names of variables specified in the random parameter logit model.
[b] The variable was measured in 10 square inches.

Table 2.2. Sample Demographics

		Survey Sample	U.S. Population
Gender	Male	41.45%	48.57%
	Female	58.55%	51.43%
Age	18-24	12.55%	12.83%
	25-34	19.59%	17.99%
	35-44	20.24%	17.23%
	45-54	21.97%	19.01%
	55-64	14.29%	16%
	65 or above	11.36%	16.95%
Education[a]	Graduate School	15.15%	9.61%
	Bachelor's degree	27.60%	18.14%
	Some college	37.34%	28.49%
	High school degree	18.72%	30.41%
	Lower than high school	1.19%	13.34%
Household Income	$0-10,000	7.14%	7.78%
	$10,000-24,999	20.56%	17.91%
	$25,000-49,999	28.25%	24.72%
	$50,000-74,999	18.83%	17.74%
	$75,000-99,999	9.96%	11.43%
	$100,000-199,999	12.45%	16.52%
	$200,000 or above	2.81%	3.90%

Source: U.S. Census Bureau, Annual Demographic Survey.
[a] The percentages for the U.S. population include only those 18 years of age and older.

Table 2.3. Items Related to the Treatment of Farm Animals

Items	Average ranking (7 = most important, …, 1 = least important)	% of respondents ranking as the *most* important	% of respondents ranking as the *least* important
Receive fresh and clean food and water	4.41	38.5%	25.1%
Receive treatment for injury and diseases	4.32	8.7%	5.7%
Are provided comfortable shelter	3.97	7.7%	9.6%
Are protected from being harmed by other animals	3.96	6.5%	7.3%
Are allowed to access outdoors	3.93	6.7%	7.3%
Are allowed to exhibit natural behaviors	3.75	8.3%	11.8%
Are raised in ways to keep our food costs low	3.66	23.7%	33.2%

Table 2.4. Factors Associated with Attitudes toward Animal Welfare

Factor/Questions	Average score	% response	Factor weight
Perceived Quality of Animal Welfare-Friendly Products *(PQTY)* (α= 0.91)			
"I believe that food products produced in an animal-friendly environment: [a]		"Somewhat" or "Completely Agree"	
Are from healthier farm animals."	4.34	83.56	0.800
Are healthier for humans."	4.20	77.39	0.797
Are from happier farm animals."	4.19	77.47	0.773
Are of better quality."	4.10	75.69	0.820
Are better for the environment."	3.96	65.34	0.766
Taste better."	3.79	59.13	0.716
Perceived Impacts of Management Practices on Hen Welfare *(PMNT)* (α= 0.82)			
Based on your understanding, how would the following activities affect the welfare of laying hens?[b]		"Somewhat" or "Definitely Worsen"	
Hens are housed in cages, instead of not being caged.	3.42	49.76	0.772
Hens' beaks are trimmed.	3.43	43.87	0.804
Hens are withheld from feeding or given less nutritive diet so that they molt to regulate production of eggs.	3.78	62.47	0.810

[a] The responses were: 1 = *completely disagree*, 2 = *somewhat disagree*, 3 = *neutral*, 4 = *somewhat agree*, 5 = *completely agree.*
[b] The responses were: 1 = *definitely improve*, 2 = *somewhat improve*, 3 = *no impact*, 4 = *somewhat worsen*, 5 = *definitely worsen.*

Table 2.5. Knowledge of Housing Systems and Environmental Impact

	% response	% response
Please indicate the levels at which you agree or disagree with the following statements:[a]		
	Incorrect	"Neutral"
"Hens that are allowed outdoor access generate less air emissions (for example, ammonia emissions and dust level) than hens that are confined indoors."[b]	49.19	41.66
"Hens that are not caged use less heat and feed than hens that are confined in cages."[c]	46.75	44.59
"Hens that are allowed outdoor access use energy and land less efficiently than hens that are housed inside."[d]	29.06	41.31
	"Somewhat" or "Completely Agree"	
"I would like to purchase animal welfare-friendly products even if the procedure places a heavier burden on the environment."	27.08	48.25

[a] The responses were on a 5-point scale: *completely disagree*, *somewhat disagree*, *neutral*, *somewhat agree*, and *completely agree.*
[b] A false statement. Thus, responses of "somewhat agree" and "completely agree" are incorrect.
[c] A false statement. Thus, responses of "somewhat agree" and "completely agree" are incorrect.
[d] A true statement. Thus, responses of "somewhat disagree" and "completely disagree" are incorrect.

Table 2.6. Descriptive Statistics of the Heterogeneity-in-Means Variables

Variable	Definition	Mean	St. dev.	Min	Max
Age	Midpoint of age ranges 18-24, 25-34, 35-44, 45-54, 55-64, 65-84	44.26	16.07	21.00	74.50
Bplus	1 if Bachelor's degree or higher, 0 otherwise	0.43	0.49	0.00	1.00
Fem	1 if female, 0 otherwise	0.59	0.49	0.00	1.00
Income	Midpoint of annual household income ranges in $10,000: 0.5-1, 1-2.4999, 2.5-4.9999, 5-7.4999, 7.5-9.9999, 10-19.9999, 20-50	6.37	6.44	0.75	35.00
INFO	1 if received the information, 0 otherwise	0.51	0.50	0.00	1.00
PMNT	Factor representing "perceived impacts of management practices on hen welfare," average of items included in the factor (see table 4)	3.54	1.01	1.00	5.00
PQTY	Factor representing "perceived quality of animal welfare friendly products," average of items included in the factor (see table 4)	4.10	0.76	1.00	5.00

Table 2.7. Estimated Random Parameter Logit Parameter Distributions

Variables	Coefficient		Std. error
Intercept (fixed)	5.38	***	0.18
Price (fixed)	-2.04	***	0.07
Color (random)	-0.37	***	0.06
Standard deviation	1.08	***	0.07
Organic (random)	0.20	***	0.06
Standard deviation	0.78	***	0.08
Vegetarian (random)	-0.11	*	0.07
Standard deviation	1.08	***	0.08
Access (random)	0.08		0.32
Standard deviation	0.71	***	0.07
Heterogeneity-in-mean			
Fem	-0.16	*	0.09
Age	-0.00		0.00
Income	-0.00		0.01
Bplus	-0.05		0.09
PQTY	0.11	*	0.06
PMNT	-0.00		0.04
INFO	0.17	*	0.09
Cagefree (random)	-0.11		0.38
Standard deviation	1.06	***	0.07
Heterogeneity-in-mean			
Fem	-0.07		0.11
Age	-0.00		0.00
Income	0.01		0.01
Bplus	-0.07		0.11
PQTY	0.20	***	0.07
PMNT	0.11	**	0.05
INFO	-0.10		0.11

Table 2.7. *Cont*.

Variables	Coefficient		Std. error
Density (random)	0.12	***	0.03
Standard deviation	0.06	***	0.00
Heterogeneity-in-mean			
Fem	-0.02	**	0.01
Age	-0.001	***	0.00
Income	-0.001		0.00
Bplus	-0.001		0.01
PQTY	-0.01		0.00
PMNT	-0.02	***	0.00
INFO	0.02	**	0.01
NoMolting (random)	0.26		0.35
Standard deviation	0.77	***	0.08
Heterogeneity-in-mean			
Fem	0.35	***	0.10
Age	-0.00		0.00
Income	0.00		0.01
Bplus	-0.07		0.10
PQTY	-0.06		0.06
PMNT	0.22	***	0.05
INFO	-0.04		0.10
Number of observations	5,544		
Log likelihood function	-5850.63		
McFadden Pseudo R-squared	0.24		
Akaike Information Criterion	2.13		

Note: single, double, and triple asterisks (*, **, ***) represent significance at the 10%, 5%, and 1% level.

Table 2.8. Statistics of Simulated WTP Distributions

Attributes	Mean	St. Dev.	Max	Min	Prob (<0)
All sample (*n* = 924)					
Color	-0.18	0.33	0.76	-1.26	0.71
Organic	0.10	0.20	0.83	-0.66	0.28
Vegetarian	-0.05	0.33	0.96	-0.96	0.59
Sub-samples by information treatment					
Received no additional information (*n* = 499)					
Access	0.16	0.19	0.76	-0.40	0.19
Cagefree	0.51	0.36	1.63	-0.54	0.07
Density	-0.006	0.02	0.05	-0.09	0.57
NoMolting	0.40	0.25	1.17	-0.26	0.06
Received additional information on environmental impacts (*n* = 475)					
Access	0.25	0.20	0.92	-0.29	0.11
Cagefree	0.47	0.35	1.46	-0.53	0.08
Density	0.002	0.02	0.06	-0.07	0.41
NoMolting	0.35	0.25	1.16	-0.34	0.07
Sub-samples by quality perceptions of products from an animal-friendly environment					
PQTY >3 (*n* = 799)					
Access	0.22	0.20	0.92	-0.40	0.14
Cagefree	0.51	0.36	1.63	-0.54	0.07
Density	-0.003	0.02	0.05	-0.09	0.50
NoMolting	0.37	0.25	1.17	-0.34	0.07
PQTY ≤ 3 (*n* = 125)					
Access	0.14	0.19	0.69	-0.30	0.19
Cagefree	0.40	0.33	1.39	-0.33	0.06
Density	0.004	0.02	0.06	-0.06	0.40
NoMolting	0.38	0.24	0.96	-0.28	0.03
Sub-samples by impacts of management practices on hens' welfare					
PMNT >3 (*n* = 587)					
Access	0.20	0.20	0.92	-0.40	0.15
Cagefree	0.52	0.37	1.63	-0.54	0.07
Density	-0.008	0.02	0.05	-0.09	0.59
NoMolting	0.45	0.23	1.17	-0.21	0.02
PMNT ≤ 3 (*n* = 337)					
Access	0.21	0.19	0.69	-0.29	0.14
Cagefree	0.44	0.32	1.41	-0.35	0.08
Density	0.009	0.02	0.06	-0.08	0.31
NoMolting	0.24	0.22	0.88	-0.34	0.13

Note: The *PQTY* factor is measured on a 5-point scale, with higher values indicating more favorable perceptions. The *PMNT* factor is measured on a 5-point scale, with higher values indicating more negative perceptions of these management practices

Chapter 3 - Consumer Responses to Multiple Labels Accounting for Interaction Effects

Introduction

In food markets, where it is difficult, if not impossible, for consumers to be fully informed about product attributes, consumers rely on various sources of information to evaluate prospective purchases. Product quality can be categorized into search, experience, and credence attributes (Nelson, 1970; Darby and Karni, 1973). Consumers can fully assess search attributes (e.g., color or size) before purchase and judge experience attributes (e.g., taste or tenderness) during or after purchase, but they may not be able to evaluate credence attributes (e.g., organic or cage-free) even after purchase. Thus, food labels play an important role in providing reliable information associated with attributes and guiding product selection for consumers.

Food markets have become increasingly differentiated because of consumers' concerns about health impacts, food safety, animal welfare, and environmental issues. For example, organic food has become a popular food category, and the sales of organic food and beverages have increased from about $1 billion to $26.7 billion in the past two decades (Meas *et al*., 2014). Consequently, various labels have been developed to inform consumers, particularly about preferred credence attributes. The egg market is a good example of this general trend. Current egg labeling includes mandatory and voluntary labeling. The Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture (USDA) requires seven egg product labels, including official identification, ingredients statement, and nutrition information (USDA, 2007). Many additional voluntary labeling programs are available for egg producers to distinguish their products in the market; for example, the USDA allows eggs to be labeled as certified organic if they are produced through methods approved and overseen by the USDA National Organic

Program (USDA, 2012a). Under the verification of the FSIS, the USDA also allows for voluntary labels such as cage-free, natural, and pasture-raised (USDA, 2012b).

Several studies have investigated consumer preferences on egg attributes and found that many consumers are willing to pay a positive premium for most labeled credence attributes, including organic eggs (Andersen, 2011), omega-3 eggs (Asselin, 2005), and eggs produced using methods believed to enhance animal welfare (Heng, Peterson, and Li, 2013). However, as increasing number of labels have emerged in the market, questions remain regarding consumer preferences for labeled attributes in the context of multiple labels. A question of interest is whether or not certain combinations of the labels are subject to interaction effects? If so, are these effects substitute or complementary? Previous studies of product attributes have provided some clues. Some findings suggest that the value associated with more than one attribute is smaller than the sum of values of each label in isolation (e.g., Nilsson, Foster, and Lusk, 2006; Bernard and Bernard, 2009). Willingness-to-pay for the same product varied with additional attribute was presented (Gao and Schroeder, 2009). These findings could be due to consumers' diminishing marginal patience for reading labels (Lusk, 2003), but could also result from the existence of interaction effects. To our knowledge, few studies have accounted for the interaction effects into their investigation of consumer preferences.

If consumers perceive overlapping information or concepts from two labels, we would expect a substitution effect between the two, which would lead to a smaller premium for the combination than the sum of each claims singly. In cases where some labels do not provide any additional information because another label already implies the presence (or absence) of a given attribute, we can regard them as redundant. For example, hormones are not administered to pigs and egg-laying hens in the United States, which means that all egg and pork products in the

market are naturally hormone-free. Yet some pork and eggs are labeled as hormone-free, while others are not. Similarly, certified organic products are required to be hormone-free and antibiotics-free, which are indicated on some food products in addition to the organic certification, but not on others.

In the case of eggs, besides the aforementioned case of the hormone-free label, a cage-free label appearing with an organic label is another example of redundancy. According to the Organic Production and Handling Standards (USDA, 2012a), certified organic eggs are produced by hens living in a cage-free environment, which indicates that organic eggs are cage-free by definition. Thus, using the cage-free label in conjunction with the organic label is redundant, yet some suppliers affix both labels on the cartons, whereas others may only label it as organic. Depending on consumers' perceptions of redundant labels, such labels could yield positive premium and complementary effect instead of substitution effect.

This study uses a survey of a panel of U.S. consumers to examine consumer preferences on labeled credence attributes in the context of multiple labels for eggs. The goal of this study is threefold: to assess how consumers' valuation of selected attribute labels in a multi-attribute setting, including redundant labels; to examine the interaction effects between labeled attributes; and to determine values of various label bundles when interaction effects are taken into consideration. A survey with a choice experiment was developed for the study and administered online to randomly selected individuals nationwide. The responses were analyzed using a latent class model accounting for heterogeneity in consumers' preferences.

Our results show that consumer preferences were heterogeneous and our sample was best categorized into four classes, which were named "Attribute Seekers," "Price Checkers," "Local Supporters," and "Combination Responders." All respondents valued the locally produced label,

the majority of them valued cage-free claims, and nearly half valued the certified organic label. The hormone-free claim, an example of redundant labeling, was valued by over half of the respondents, and even the Price Checkers valued the label if it was bundled with organic or omega-3 claims. Label combinations were found to affect certain consumers, and such effects differed across classes. Cage-free and hormone-free claims were perceived as complements by Attribute Seekers, while organic and locally produced claims were perceived as substitutes by Price Checkers and Combination Responders. The most valued label combination was the organic and cage-free claims by Attribute Seekers, while other groups valued the cage-free and locally produced claim bundle the most.

Literature Review

There has been a great number of labels in the food market, including health claims, animal-welfare, and additive related claims. In the egg industry, the production of specialty eggs has accounted for nearly 16% of the entire egg market by 2005 (Chang, Lusk, and Norwood, 2010). As eggs are an important source of protein for many consumers' daily nutrition, health related claims have become a popular approach to meet consumer's desires for health information. One of the most popular differentiation in this context is organic products. The sales of organic egg growth rate averaged at 19% between 2000 and 2005 (Oberholtzer, Greene, and Lopez, 2006). Previous studies have shown that consumers perceived organic eggs as healthier products and would pay a premium (Andersen, 2011; Gracia, Barreiro-Hurle, and Lopez-Galan, 2014; Heng, Peterson, and Li, 2013). Nutrient-added eggs are another group of differentiated products with a similar focus, yet previous studies found inconsistent consumer preferences for such specialty products. For example, both Canadian and U.S. consumers were found to be willing to pay a premium for omega-3 enhanced eggs (Asselin, 2005; Chang, Lusk, and

Norwood, 2010), while a study in Spain found consumers did not value nutrient-added eggs, including omege-3 and vitamin-added specialties (Mesias *et al*., 2010).

Animal-welfare related labels reflect consumer concerns over animal living conditions and have become increasingly common among meat and dairy products. In particular, the cage-free label has become a commonly used label to inform consumers regarding laying hen's welfare. In 2013, the sales of cage-free eggs accounted for 4.3% of the industry revenue (IBISWorld, 2014). While some previous studies found that consumers appear to be willing to pay some premium for these welfare-related labels (Gracia, Barreiro-Hurle, and Lopez-Galan, 2014; Heng, Peterson, and Li, 2013), others reached different conclusions (e.g., Chang, Lusk, and Norwood, 2010).

The "local" claim continues to gain public attention today, as consumers desire to know where their food come from. The term "local," while yet to be officially defined, could refer to physical distance or political boundaries. For example, some authors use physical distance to describe local foods as any food produced and sold within a 30-150 mile radius (Chambers *et al*., 2007), while others use administrative boundaries, such as counties, states, and regions to define local foods (Martinez *et al*., 2010). In this study, we use state boundary to explore consumers' preferences toward local food origin and define "local" eggs as those produced and sold within the same state. Previous studies have consistently found that consumers were willing to pay a premium for local produced food. Bond, Thilmany, and Bond (2008a) found that consumers valued local and organic melon, and the premium for locally grown melon was greater than that for organic product. Meas *et al*. (2014) found consumers were willing to pay for blackberry jams that were produced in sub-state regions and more narrowly defined local. Gracia, Barreiro-Hurle,

and Lopez-Galan (2014) reported that consumers in Spain valued local and regional produced eggs.

Additive is another concern by consumers regarding food products, and previous works have showed that consumers generally value food produced without additives. Dhar and Foltz (2005) suggested that consumers on average valued rBST-free milk. Bond, Thilmany, and Bond (2008a) found that the pesticide-free attribute was highly valued by majority respondents in their survey regarding melon. Lusk and Fox (2002) found that the majority of respondents valued beef from cattle that have not been administered growth hormones. Lusk, Norwood, and Pruitt (2006) found that consumers placed substantial premiums on pork produced without antibiotics.

However, different from other livestock products, poultry is prohibited to be treated with hormones by federal regulations, which makes all eggs in the market to be hormone-free automatically (USDA, 2013). Thus, the "hormone-free" label on eggs is a case of redundant label. Since we are not aware of studies examining the issues with redundancy in labeled information, particularly in the case of eggs, this study uses hormone-free and the bundle of organic and cage-free claims to examine consumer's valuation for redundant labels.

Questions remain regarding consumer preferences for attributes in the context of multiple labels, especially when interaction effects between two labels are taken into consideration. Previous studies on total premium for a bundle of attributes have suggested the possible existence of interaction effects. Nilsson, Foster, and Lusk (2006) studied the marketing opportunities for certified pork chops and found that 84% of respondents in their survey sample experienced a decreasing marginal utility as the number of credence attributes increased. Gao and Schroeder (2009) revealed that consumer WTP for U.S. beef decreased then increased as additional attribute information was provided, but the relative importance ranking of attributes

did not change. Bernard and Bernard (2009) used auction experiments to examine the demand relationship and WTP for organic, rBST-free, no antibiotics used, and conventional milk. Their results suggested the combined premium for the complete bundle of organic, rBST-free, and antibiotics-free was less than the premium for organic alone. More recently, Gracia, Barreiro-Hurle, and Lopez-Galan (2014) found that the majority of respondents in a Spanish study preferred local egg products and were willing to pay a higher premium for the combination of organic and local claims than each claim singly. In contrast, Meas *et al*. (2014) found regional claims and organic labels as substitutes using a survey for processed blackberry jam in Ohio and Kentucky. They also found that the "small farm" attributes appeared to be a substitute for organic and local attributes, which was consistent with a belief that consumer purchase organic or local products to support small farms.

Most studies have overlooked the potential substitution and complementary effects in multi-attribute settings, while such interaction effects could be sizable to offset the main effects (Meas *et al*., 2014). So far, only a few studies have investigated the interaction effects between attributes, and they all focused on the effects between organic and other attributes, such as additives (Bernard and Bernard, 2009; Bernard, Pesek Jr, and Onken, 2011), health claims (Bond, Thilmany, and Bond, 2008b), and locally produced claim (Gracia, Barreiro-Hurle, and Lopez-Galan, 2014; Meas *et al*., 2014). Our study contributes to the literature by investigating interaction effects among various attribute categories, including organic, animal-welfare, origin, nutrient-enhanced and additives. Moreover, our work is one of the first studies to examine the interaction effect between animal-welfare and other claims. To our knowledge, only one study (Satimanon and Weatherspoon, 2010) examined the interaction effect involving an animal-welfare attribute, but they only included the bundle of cage-free and organic claims, with no

other combinations. As animal-welfare is becoming a popular category in the livestock and dairy markets, our results will provide useful information and strategies for producers to advertise attributes effectively.

Survey Design

The survey consisted of screening questions, general questions, demographic questions, and a choice experiment. The screening questions narrowed the respondents to individuals with recent experience in purchasing eggs. The general questions collected information on shopping behavior and attitudes toward and perceptions of food product labeling, and the demographic questions collected information such as gender, age, education, household annual income, and geographic areas of residence.

Choice experiments have been widely applied to investigate consumer preferences and estimate marginal values of attributes (Louviere and Hensher, 1983; Loureiro and Umberger, 2005; Hu *et al.*, 2004). Our choice experiment was designed to estimate how consumers choose egg products that varied in price, color of egg shell, and packaging, as well as in credence attribute labels. Each egg product consisting of dozen eggs was pictured in color to visually provide information on shell color (white or brown) and package materials (paper, plastic, or Styrofoam) with a verbal description of these attributes accompanying the image (e.g., "White, Paper"). The packaging attribute aimed to examine consumer's attribute towards sustainable packaging materials. As paper and paperboards are easier to recycle than plastic or Styrofoam, paper packaging is considered to be more environmental friendly (Satimanon and Weatherspoon, 2010). Yet, plastic and Styrofoam packaging might be perceived as offering better protection for eggs. An example of the survey scenario is presented in Figure 1.

The labels on the product indicating price and credence attributes were listed underneath the product image. Three price levels ($2.09, $2.49, and $2.89) were specified, with the mid-level of price referencing the national average retail price of white omega-3 enhanced eggs reported by the USDA during the week of June 1, 2012, when the survey was developed (USDA 2012c). The lower and higher levels of prices were set at 40-cent intervals from the mid-price level. Four types of credence attribute labels representing the most prevalent attributes in the egg market were included for respondent consideration: health-related (certified organic, omega-3, no label), animal welfare (cage-free, no label), additives (hormone-free, no label), and origin (from your state, from outside your state).

The levels of attributes are summarized in Table 3.1. With all possible levels for the entire attributes, a full factorial design included 432 (=3×2×3×2×2×2×3) product profiles. A macro in SAS 9.2 suggested 72 profiles for a fractional factorial design, which yielded a D-efficiency score over 99%. The profiles were grouped into 24 choice scenarios with three products each, which were blocked into three sets of eight choice scenarios to minimize response fatigue. For each scenario, respondents were asked to choose from three products with different attributes and a "Not buy any of the three" option. Concise and relevant information regarding each attribute were provided prior to the choice scenarios, and the full statement can be found in the Appendix. We informed the respondents in the statement that all egg laying hens in the U.S. are not given hormones, and certified organic eggs are produced by hens living in a cage-free environment.

The Model

The theory of utility maximization assumes that consumers choose the alternative that would provide them with the highest level of utility. Following Lancaster (1966), a product is

composed of several attributes, and consumer's utility associated with the product can be decomposed into separate utilities for each attribute. Traditionally, the stated preferences can be analyzed using multinomial logit (MNL) models, which can describe the utility of consumer *n* choosing alternative *j* in the choice scenario *t* as:

$$U_{njt} = \beta X_{njt} + \epsilon_{njt} \tag{3.1}$$

where β is a vector of taste parameters assumed to be constant across individuals (McFadden, 1974), $X_{njt}$is a vector of observable attributes, and ϵ_{njt} is a random, unobservable component assumed to be an independent identically distributed (i.i.d.) extreme value over all alternatives and choice situations.

However, as many empirical papers have showed that consumer preferences for food products are heterogeneous (Gracia, Barreiro-Hurle, and Lopez-Galan, 2014; Loureiro and Umberger, 2005; Nilsson, Foster, and Lusk, 2006; Heng, Peterson, and Li, 2013), the assumption that consumer's preferences are homogeneous is not realistic. Two popular discrete choice approach that account for consumer heterogeneity are the random parameter logit (RPL) and latent class models (LCM). Both models have been widely applied in consumer studies to identify different segments of consumers based on their heterogeneous tastes (Heng, Peterson, and Li., 2013; Tonsor, Olynk, and Wolf, 2009; Ouma, Abdulai, and Drucker, 2007; Gracia, Barreiro-Hurle, and Lopez-Galan, 2014). We use the two models to investigate consumer values subject to alternative model assumptions.

The RPL model allows for random taste variation within the respondents. The application of the equation (3.1) in a RPL can be presented as:

$$U_{njt} = \beta_n X_{njt} + \varepsilon_{njt} \tag{3.2}$$

where β_n is a vector consist of variable coefficients representing the individual's taste. The researchers can specify the probability density of the coefficient vector $f(\beta|\theta)$, where θ is the parameter vector that describes this distribution of β across individuals. Following Hensher and Greene (2001), the probability of individual *n* choosing alternative *j* is an integral of standard logit probabilities over the parameter densities such that:

$$P_{nj}(\theta) = \int (\frac{e^{X_{nj}\beta_n}}{\sum_{k=0}^{J} e^{X_{nk}\beta_n}}) f(\beta_n|\theta) d\beta_n. \tag{3.3}$$

We specify β_n in equation (3.2) to vary following a normal distribution. To focus on the heterogeneity in preferences for labeled attributes, the constant, the price coefficient, and the coefficients on non-labeled attributes are specified to be fixed.

While RPL assumes continuous consumer heterogeneity, LCM assumes discrete consumer heterogeneity (Train, 2003). In the LCM, consumers are assumed to belong to different classes based on their preferences. Consumers within the same class have homogeneous preferences, but preferences vary across classes (Boxall and Adamowicz, 2002; Ouma, Abdulai, and Drucker, 2007). Thus, the utility of an individual *n* in class *s* choosing alternative *j* in choice scenario *t* can now be adjusted as:

$$U_{njt|s} = \beta_s X_{njt} + \varepsilon_{njt|s} \tag{3.2}$$

where β_s is a class-specific parameter vector. Assuming that within the class, individual choices from one scenario to another are independent (Greene and Hensher, 2003), the probability that individual *n* chooses alternative *i* from a set *J* in choice scenario *t*, conditional on the individual being in class *s*, can be represented as:

$$P_{nit|s} = \prod_{t=1}^{T} \frac{\exp(\beta_s x_{nit})}{\sum_{J=1}^{J} \exp(\beta_s x_{njt})} \tag{3.3}$$

Although we do not observe the classes directly, class probabilities are specified by the multinomial logit as:

$$P_s = \frac{\exp(\alpha_s' Z_n)}{\sum_{s=1}^{S} \exp(\alpha_s' Z_n)} \tag{3.4}$$

where $Z_n$is a set of individual-specific characteristics and α_s is the class-specific utility parameters.

In this study, an individual's utility was specified for choosing one of three egg products or "none of these three" option with price, visible attributes, credence attribute labels, and interaction terms among the credence attributes, which can be written as:

$$U_{njt} = \beta_0 OptOut_{jt} + \beta_1 Price_{jt} + \beta_2 Brown_{jt} + \beta_3 Paper_{jt} + \beta_4 Styro_{jt} + \beta_5 Organic_{jt} + \beta_6 Cagefree_{jt} + \beta_7 NoHorm_{jt} + \beta_8 Omega_{jt} + \beta_9 Ownstate_{jt} + \gamma_{56} Organic_{jt} \times Cagefree_{jt} + \gamma_{57} Organic_{jt} \times NoHorm_{jt} + \gamma_{59} Organic_{jt} \times Ownstate_{jt} + \gamma_{67} Cagefree_{jt} \times NoHorm_{jt} + \gamma_{69} Cagefree_{jt} \times Ownstate_{jt} + \gamma_{79} NoHorm_{jt} \times Ownstate_{jt} + \gamma_{68} Omega_{jt} \times Cagefree_{jt} + \gamma_{78} Omega_{jt} \times NoHorm_{jt} + \gamma_{89} Omega_{jt} \times Ownstate_{jt} + \varepsilon_{njt} \tag{3.5}$$

where *Organic*, *Cagefree*, *NoHorm*, *Omega*, and *Ownstate* are dummy variables and representing egg credence attribute labels, with the value of 1 indicating their presence. *Brown*, *Paper*, and *Styro* are dummy variables representing visible attributes of shell color and package materials. All binary variables are coded using effect-coding to avoid confounding effects between constant and the binary variables.[4] The interaction terms are specified to account for the interaction effects between credence attribute labels. If two claims are providing overlapping or competing concepts or information, the combination of two claims will yield a smaller utility

[4] In effect coding, a binary variable takes a value of 1 when attribute presents, -1 when the base level applies (Tonsor, Olynk, and Wolf, 2009). For example, the binary variable *Cagefree* takes 1 when the claim presents, -1 otherwise. Interested readers are encouraged to refer to Bech and Gyrd-Hansen (2005) for details.

than the sum of individual effect from separate claims, and such negative interaction effect suggests the two claims as substitutes. On the other hand, if two claims are providing complementary information, the combination of two claims will yield a greater utility than the sum of individual effects from separate claims. Such positive effect implies a complementary effect. The *Price* represents the price level given for each alternative. Since the choice design allowed for a no-purchase option, an *OptOut* term is specified to take a value 1 for the no-purchase option, and 0 otherwise.

Willingness-to-Pay

Estimated parameters can be used to calculate the mean willingness-to-pay (WTP), which is conventionally a negative ratio between the attribute and price parameters. In this study, the parameter for labeled attribute *k* is multiplied by two in the WTP ratio due to effects coding (Lusk, Roosen, and Fox, 2003), which can be written as:

$$WTP_k = -\frac{2 \times \beta_k}{\beta_1}, \qquad k = 5, \dots, 9 \tag{3.6}$$

Following Gracia, Barreiro-Hurle, and Lopez-Galan (2014), to consider the interaction effect in the presence of multiple labels, the total WTP for the bundle of labeled attributes *k* and *m* can be calculated by the sum of individual label WTP and the interaction term, which can be written as:

$$WTP_{km}^{total} = -2 \times \frac{\beta_k + \beta_m + \gamma_{km}}{\beta_1}, \qquad k, m = 5, \dots, 9 \tag{3.7}$$

For example, to calculate consumer's preference on the combination of organic and cage-free labels, the total WTP can be calculated as $WTP_{56}^{total} = -2 \times \frac{\beta_5 + \beta_6 + \gamma_{56}}{\beta_1}$.

In order to determine statistical significance of estimated WTP, the 95% confidence intervals for WTP values were calculated by the Krinsky-Robb method with 1,000 draws using NLOGIT 4.0 (Greene, 2007).

Results

The survey was administered online by Research Now to collect a representative, nationwide sample. After a pre-test, the survey was launched in June 2012 and returned 608 completed responses. Because the average completion time was nearly 19 minutes, the responses completed in less than five minutes were discarded to prevent responses from individuals that skimmed over questions, leaving us with a total of 589 responses.

Our sample consisted of higher proportions of female and highly educated respondents than the U.S. population. These sample characteristics are not unlike other survey work on food purchases, because the female is the primary food buyer in many households, and people with higher educational attainment may be more likely to express their viewpoints. According to Table 3.2, the mean age (51.1 years) of our respondents (above 18 years old) as well as the mean household income level ($92,400) were higher than the national levels, where the mean age of population above 18 years old was 46.7 years and median household income was $50,502 in 2010 (U.S. Census Bureau, 2011; 2012).

Model Parameter Estimates

Random parameter logit and latent class models were estimated using NLOGIT 4.0 (Greene, 2007), and the results are presented in Table 3.3. Based on a likelihood ratio test ($p<0.0001$), the interaction effects were jointly statistically significant. Looking at the RPL results, the price coefficient was negative and significant, indicating higher prices generate disutility. The coefficients on three non-credence attributes and mean coefficients on four of five

credence attributes were statistically significant at the 5% level. The average consumer was found to prefer white-shell eggs that were produced in an organic system, under cage-free condition, without hormone, from their own state, and packaged in paper. The only interaction term statistically significant at the 1% level was *Organic*×*NoHorm*, and the negative coefficient indicates that consumers perceive organic and hormone-free attributes to be overlapping concepts. Statistical significance of standard deviations for all considered attribute labels indicates that respondents' preferences toward these labels were indeed heterogeneous.

The LCM results are also reported in Table 3.3. Following Boxall and Adamovicz (2002), we used Bayesian information criterion (BIC) to identify the number of classes to be used in LCM. The four-class model was finally selected with the lowest BIC among models with two to five classes. The socio-demographic variables (e.g., age, education, household income) were initially included to identify the class membership equation (3.4), but none of them were not statistically significant, suggesting class probabilities did not depend on observed demographics. Thus, the class membership was estimated without demographics.

The results for the first class with the largest class probability of 47.5% were the most similar to the RPL results. The estimated main effect coefficients are all statistically significant at the 1% level, except the *Omega* coefficient. Members in this class valued brown-shell eggs produced in an organic system, under cage-free condition, without hormone, from their own state, and packed in paper cartons, followed by plastic ones. Two interaction terms *Organic*×*NoHorm* and *Cagefree*×*NoHorm*, were statistically significant at the 5% and 1% levels, respectively. The negative coefficient for *Organic*×*NoHorm* indicates that consumers perceive organic and hormone-free claims as competing concepts, similarly as suggested by the RPL model. The positive coefficient for *Cagefree*×*NoHorm* indicates that consumers in this

class value the combination of cage-free and hormone-free labels more than the sum of separate labels. As consumers in this class appeared to value most of the credence attributes, this class is referred to as the "Attribute Seekers."

The second class, estimated to constitute 26.8% of the sample, yielded the price parameter that was at least over four times as large as that in other groups, indicating that members of this class are relatively more price sensitive than others. Correspondingly, this class is referred to as the "Price Checkers". The parameter estimates for the labeled attributes *Cagefree*, *NoHorm*, and *Ownstate* are statistically significant at the 1% level, *Omega* at the 5% level, and *Organic* at the 10% level. A member of second class prefers eggs in paper cartons. Different from the first class, members in this class devalued the hormone-free label. But, the coefficients on the interaction between *NoHorm* and *Organic*, and *NoHorm* and *Omega* were respectively positive and statistically significant at the 1% level, indicating that a class member would value the hormone-free label if it was bundled with health-related labels. Coefficients of *Organic*×*Cagefree* and *Organic*×*Ownstate* were negative and significant at 1% level, suggesting overlapping and competing benefits perceived from organic and cage-free or local labels.

The third class had the smallest class probability of 9.2%. Regarding non-credence attributes, a member of this class preferred paper packed, white-shell eggs. The main effect parameter estimates for *Cagefree* and *Ownstate* were positive and statistically significant at the 5% and 1% levels, respectively. The magnitude of *Ownstate* coefficient was approximate four times as large as that of *Cagefree*, and was also the largest value of *Ownstate* coefficients among all four classes. No interaction terms were statistically significant. Thus, this class might represent consumers who primarily care whether eggs are produced from their own state and little about all other labels. This class is referred to as the "Local Supporters".

The fourth class represented 16.6% of respondents. A member of this class preferred white-shell eggs, packaged in Styrofoam cartons. Regarding interaction terms, five combination of labels are statistically significant at the 5% level and one at the 10% level. Negative parameters for *Organic*×*Ownstate*, *Cagefree*×*NoHorm*, and *NoHorm*×*Ownstate* indicate that the fourth class members not only perceived organic and local food as competing attributes as the Price Checkers, but also perceived cage-free and local attributes as substitutes for the hormone-free label, which is different from the Attribute Seekers. On the other hand, positive parameters for *Cagefree*×*Ownstate*, *Omega*×*Cagefree*, and *Organic*×*Cagefree* suggest members value the pairing of the cage-free label with organic, locally produced, or omega-3 enhanced claim, although they do not value cage-free or omega-3 claim alone and the *Organic* coefficient is statistically significant at the 10% level. Thus, although cage-free claim is redundant given the organic claim, this combination was still valued by this group. Respondents in this class appear relatively more sensitive to combinations of labels than other classes, and thus, this class is referred to as the "Combination Responders".

Willingness-to-Pay Estimates

The calculated mean WTP estimates for each labeled attribute and interactions are presented in Table 3.4. The RPL model indicates that average respondents would pay a significant positive premium for all labeled attributes, ranged from $0.25 per carton to $0.42 per carton, except omega-3. The only statistically significant interaction effect is associated with the bundle of organic and hormone-free labels.

Based on the LCM, we found that respondents' premiums for different attributes differ considerably in magnitude and sign across different classes. Similar to the RPL results, the Attribute Seekers preferred all labeled attributes except omega-3, but the premiums were higher,

ranging from $0.62 per carton to $0.98 per carton. This group was willing to pay the highest premiums for all credence attributes, with the exception of the amount Local Supporters were willing to pay for the locally produced label. The Price Checkers were willing to pay a positive premium for all labeled credence attributes, except hormone-free. However, members were only willing to pay small premium for labeled attributes, ranged between $0.07 per carton to $0.17 per carton. Despite the small magnitudes, premiums were statistically different from zero. The Local Supporters only would like to pay a positive premium for the local label. Combination Responders were found to be willing to pay a positive premium for hormone-free and local produced eggs, and the magnitude of premiums situated between the first two groups.

Regarding the main/linear effects, all classes were willing to be a premium for the local claim. Attribute Seekers were willing to pay the second highest for the local label ($0.87 per carton) after the cage-free claim. Other three groups would like to pay the highest premium for local claim, and the premium ranged from $0.17 per carton to $1.32 per carton; it is the Local Supporters who constitute only a small proportion of respondents, with the distinctly high willingness to pay. Even though state boundary is a crude measure of local origin and we do not know how each respondent define local eggs, our findings are consistent with previous studies, which have consistently found that consumers were willing to pay a positive premium for local food (e.g., Bond, Thilmany, and Bond, 2008a; Meas *et al*., 2014). The local claim was also found to be substitutes for the organic and hormone-free claims (and *vice versa*). This could suggest some consumers might perceive local food as organic or additive-free products. Onozaka, Nurse, and McFadden (2010) also reported that 80% of respondents in their survey appeared to misperceive local food as organic.

In our sample, nearly 40% of the respondents stated that cage-free is a somewhat important or extremely important factor for them to choose organic eggs (Table 3.6). Moreover, they identified taste as the most important factor to buy cage-free eggs, rather than animal welfare concerns, suggesting many consumers believe that cage-free eggs taste better. As such, the cage-free claim would receive a positive premium from Attribute Seekers and Price Checkers, representing 74.3% of the sample, but not from Local Supporters and Combination Responders. When cage-free claim was bundled with other claims, combinations tend to generate extra positive premiums, except the organic and cage-free bundle among Price Checkers and the cage-free and hormone-free bundle among Combination Responders. The negative premium for interaction of organic and cage-free is not surprising, since organic eggs are naturally cage-free. Satimanon and Weatherspoon (2010) also found that consumers did not value this combination. In addition, the premium loss for the cage-free and hormone-free bundle from Combination Responders was smaller than the positive premium gained from Attribute Seekers with the largest class size., In sum, the cage-free claim not only received premium from majority of the respondents by itself, but also gained additional premium by bundling with other attribute categories from three out of four groups. If consumers buy cage-free eggs for taste, as suggested by Table 3.6, it could explain why such claim appears to be a complement for other claims.

The organic claim only would receive a positive premium from Attribute Seekers, but not from other groups. Moreover, the combination of organic and other claims tended to yield a negative premium, except the bundle of organic and hormone-free for Price Checkers. The premium discount ranged from $0.10 per carton to $0.76 per carton, and the largest premium discount was yield by the bundle of organic and local claims among Combination Responders, which was even larger than the main premium for the local claim. Such results could indicate

that the concept of organic claim might be too complex for general consumers, and when more specific claims are also presented, consumers would not value organic claim as much. These results are not different from previous works. Bond, Thilmany, and Bond (2008a) found that consumers disvalue the combination of organic and other nutrient claims. More recent studies provide support for the negative effect between organic and local produced claims (Campbell *et al*., 2014; Meas *et al*., 2014). Adams and Salois (2010) reported a general trend that consumers are turning from organic to local food as a substitute.

The hormone-free claim received a positive premium from Attribute Seekers and Combination Responders, representing 64.1% of the respondents, but a small amount of premium discount ($0.07 per carton) from Price Checkers. Although Price Checkers appear to be most discerning about redundant labels (hormone-free claim and the bundle of organic and cage-free), they were willing to pay $0.14 per carton for organic and hormone-free bundle and $0.09 per carton for omega-3 and hormone-free bundle to the total premium, respectively, which exceeded the main premium discount of the hormone-free claim. The general positive valuation of the hormone-free claim might be due to consumer's concern over additives. In our sample, over half of the respondents stated that no additives is an extremely or somewhat important factor when choosing an egg product (Table 3.6). Also, while they were presented with the information regarding the redundancy of this claim, it is possible that they did not process the information. Lastly, the omega-3 label only gained a small amount of positive premium from Price Checkers, which could explain the conflicting finding from literature regarding nutrient-added claims. Only about 23% of respondents in our sample reported that nutrient enhancement is an extremely or somewhat important factor when choosing an egg product (Table 3.6)

The total WTP of claim combinations were calculated following equations (3.7), and are presented in Table 3.5. From the RPL, all the claim combination premium are positive and statistically significant at 5% level. Average consumers would pay the highest premium for cage-free eggs that produced from local producers. Using the LCM, Attribute Seekers have similar preferences as the average consumers in RPL, valuing all of the claim combination premiums. The total WTP ranged from $0.52 per carton to $1.95 per carton. The most valued product was eggs that were produced according to the certified organic system and under cage-free condition, followed by the eggs that produced under cage-free condition and labeled as hormone-free. In the Price Checkers class, the total WTP ranged between $0.12 per carton and $0.25 per carton, which were smaller than those in other classes. The most valued product is eggs that produced under cage-free condition and from their own state, followed by the products with omega-3 added and produced under cage-free condition.

The Local Supporters group members were found to be willing to pay a positive premium only for interactions involving local label. The premium ranged between $0.8 per carton and $1.54 per carton. The most valued product is cage-free eggs produced from their own state, followed by the organic eggs that from their own state. Combination Responders were willing to pay a significant positive premium for all interactions, except for the bundle of organic and local produced claims and the bundle of cage-free and hormone-free claims. The total WTP ranged from $0.44 per carton to $0.87 per carton, and the most valued product was, similar to Price Checker and Local Supporters, cage-free eggs produced within the state, and followed by eggs with omega-3 added and hormone-free label.

Conclusion

For product differentiation to be an effective strategy for producers, it is important to understand how consumers value differentiated attributes and associated labels. Most previous studies assume away interaction effects among attributes. This study examined consumer valuation of egg attributes in cases of multiple labels accounting for various interaction effects. Our results call for detailed assessment of specific labeling strategies to ensure their effectiveness in enhancing product value. Both RPL and LCM models were applied to account for consumer heterogeneity. We found that sample respondents' preferences were heterogeneous based on both models, and from the LCM, best sorted into four classes. Given the class sizes, the preferences from the largest group (Attribute Seekers) in LCM results were similar to that from the average consumers in RPL results.

Related to our first objective, the local label gained a positive premium from all four classes, indicating universal preferences toward local food. The cage-free claim was also valued by the majority of the sample. The organic claim was valued by almost half of the sample (Attribute Seekers), while a small proportion of the sample (Price Checkers) valued the omega-3 claim. The main premium for the local label was generally larger than that for organic claim in all groups. Such results support the previously reported trend that consumers are switching from organic food to local produced food, and we would suggest local producers to market their products as locally produced eggs instead of pursuing organic certification. The hormone-free label was valued by over half of the sample, while another case of redundant label, the bundle of organic and cage-free claims led to a zero or negative premium. Such results suggest that additives continues to be an important concern for consumers and justify producer's costs for affixing such labels.

Related to the second objective, we found some significant interaction effects between labeled attributes, and such effects differ in type, value, and sign across different respondent classes. Cage-free and hormone-free claims were perceived as complements by the largest group, Attribute Seekers, but as substitutes by Combination Responders. Organic and local claims were viewed as competing concepts and substitutes for each other by both Price Checkers and Combination Responders. The local label was perceived as a complement for the cage-free claim, but as a substitute for the hormone-free claim by Combination Responders. Omega-3 and hormone-free claims are perceived as complements by Price Checkers. Given respondent's main WTP for labeled attributes, interactions could generate sizable impacts for certain groups of consumers. Since affixing labels is not free, and the costs of some labels, such as certified organic, could be considerable. Thus, producers should take such information into their consideration for the most effective labeling strategies. For example, strategies targeting the Attribute Seekers could be expected to bring positive premiums, but the same strategies would lead to zero or even negative premium in other segments.

Regarding the last objective, nearly half of the respondents were willing to pay the largest premium for eggs labeled both organic and cage-free, followed by cage-free eggs that were labeled as hormone-free. Cage-free eggs from in-state producers were the most valued product for three out of four group consumers, representing 52.6% of the sample. Hence, cage-free claim seems to be attractive in a multi-attribute setting.

Our premium estimates used stated preference, rather than revealed preference, and would be subject to potential hypothetical bias. But our findings are consistent with respondents' attitudes in our sample and previously reported trends and findings. Also, although we assume all respondents were fully informed with the meaning of labels through the statement before the

choice experiments, no additional question was included in the survey to test if they were truly aware of all the information. Test questions or a split sample approach with different presented information would be helpful and encouraged along with choice experiments in future studies. Finally, although our model accounts for consumer heterogeneity, but did not identify the characteristics of different consumer segments. Further studies could be designed to identify characteristics (e.g., demographics, attitudes) of various consumer segments and provide recommendations for producers to target specific segment.

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Appendix - Statement that Appeared Before the Choice Scenarios

In the following, you will be asked to make choices as if you would in an actual shopping situation. Suppose in a typical grocery shopping trip, you need to purchase eggs.

Foods are produced in various ways, and here is some terminology used to describe ways to distinguish how eggs are produced.

Color: almost all commercial eggshells are **white** or **brown**, which depend on the breed of hens.

Packaging: some eggs are sold in **paper cartons**, some are in **plastic cartons**, and others are sold in **Styrofoam cartons**.

Additional attributes:

Eggs are produced nationwide. Some eggs sold in the market are produced in your state, that is to say, these eggs **are from your state**. Some eggs are produced in states other than your state are **from outside your state**.

Certified organic eggs are produced by hens living in a cage-free environment and are fed organic grains without pesticides, fertilizer or animal byproducts, and this label is regulated by the U.S Department of Agriculture.

Omega-3 eggs are produced by hens that are fed a diet enhanced with omega-3 essential fatty acids, which has been showed that may help reducing the risk of heart disease by some studies.

Most eggs **without these labels** can be assumed to be produced by hens fed conventional diets which include feed ingredients, such as corn and soybean meal, fish meals and meat meals, and major minerals (e.g. Ca and P), and non-nutritive additives.

Many eggs are produced by hens that are confined in battery cages (i.e., **caged**) all the time. **Cage-free** eggs are produced by hens that are able to move freely in barns or warehouses.

Egg laying hens in the U.S. are not given hormones. Some egg cartons say that the eggs are **hormone-free**; however, this is true for all eggs in the market.

Table 3.1. Attributes of The Choice Experiment[a]

Attributes	Levels
Price	$2.09, $2.49, $2.89
Color of shell	Brown (*Brown*), White
Packaging materials	Paper (*Paper*), Styrofoam (*Styro*), Plastic
Process labeling	Organic (*Organic*), Omega-3 (*Omega*), Not labeled
Animal welfare labeling	Cage-free, Not labeled
Additive labeling	Hormone-free (*NoHorm*), Not labeled
Origin labeling	From your state (*Ownstate*), From outside your state

[a] The italicized terms are names of variables specified in the model.

Table 3.2. Descriptive Statistics of the Demographic Characteristics

Variable	Definition	Mean	St. dev.	Min	Max
Age	Midpoint of age ranges 18-24, 25-34, 35-44, 45-54, 55-64, 65-84	51.14	16.83	21.00	74.50
Education	1 if Bachelor's degree or higher, 0 otherwise	0.43	0.49	0.00	1.00
Gender	1 if female, 0 otherwise	0.58	0.49	0.00	1.00
Income	Midpoint of annual household income ranges in $10,000: 0.5-1, 1-2.4999, 2.5-4.9999, 5-7.4999, 7.5-9.9999, 10-19.9999, 20-50	9.24	8.43	0.75	35.00

Table 3.3. Estimated Parameters (Standard Error) for Random Parameter Logit Model and Latent Class Model

Variable	RPL		LCM-4 Class Model			
			Class 1 *"Attribute Seekers"*	Class 2 *"Price Checkers"*	Class 3 *"Local Supporters"*	Class 4 *"Combination Responders"*
	Coeff.	Std. Dev.	Coeff.	Coeff.	Coeff.	Coeff.
Price	-2.226***	-	-0.860***	-7.180***	-1.155***	-1.516***
	(0.065)	-	(0.104)	(0.364)	(0.206)	(0.214)
Brown	-0.298***	-	0.094***	0.065	-0.787***	-1.432***
	(0.023)	-	(0.038)	(0.089)	(0.083)	(0.071)
Paper	0.484***	-	0.532***	0.219**	0.708***	-0.005
	(0.028)	-	(0.041)	(0.104)	(0.099)	(0.076)
Styro	-0.223***	-	-0.291***	0.049	-0.290***	0.218***
	(0.028)	-	(0.042)	(0.096)	(0.094)	(0.069)
Organic	0.277***	0.484***	0.353***	0.185*	0.028	0.157*
	(0.029)	(0.042)	(0.045)	(0.101)	(0.103)	(0.089)
Cagefree	0.346***	0.465***	0.425***	0.303***	0.207**	0.003
	(0.028)	(0.060)	(0.046)	(0.082)	(0.098)	(0.094)
NoHorm	0.276***	0.397***	0.270***	-0.246***	-0.064	0.284***
	(0.020)	(0.038)	(0.036)	(0.080)	(0.073)	(0.056)
Omega	-0.071	0.319***	-0.042	0.233**	-0.161	0.084
	(0.034)	(0.040)	(0.056)	(0.123)	(0.112)	(0.077)
Ownstate	0.466***	0.421***	0.373***	0.623***	0.764***	0.416***
	(0.023)	(0.038)	(0.037)	(0.085)	(0.085)	(0.086)
Org.×Cag.	0.071	0.360***	0.060	-0.364***	-0.005	0.252*
	(0.036)	(0.050)	(0.058)	(0.110)	(0.126)	(0.134)
Org.×NoH.	-0.201***	0.142**	-0.126**	0.515***	-0.182*	-0.100
	(0.036)	(0.068)	(0.063)	(0.155)	(0.094)	(0.096)
Org.×Own.	-0.070	0.034	-0.028	-0.327***	0.030	-0.572***
	(0.038)	(0.090)	(0.062)	(0.129)	0.118	(0.141)
Cag.×NoH.	0.035	0.283***	0.112***	-0.118	-0.108	-0.193**
	(0.027)	(0.052)	(0.042)	(0.088)	(0.088)	(0.084)

Table 3.3. Cont.

Variable	Coeff.	Std. Dev.	Coeff.	Coeff.	Coeff.	Coeff.
Cag.×*Own.*	0.035	0.168*	-0.019	0.004	-0.083	0.238***
	0.025	(0.090)	(0.039)	(0.080)	(0.089)	(0.079)
NoH.×*Own.*	-0.041	0.094	-0.008	-0.048	0.000	-0.170**
	(0.031)	(0.109)	(0.054)	(0.131)	(0.080)	(0.083)
Omg.×*Cag.*	-0.033	0.541***	0.088	0.246	0.096	0.462***
	(0.049)	(0.064)	(0.076)	(0.176)	(0.128)	(0.137)
Omg.×*NoH.*	-0.012	0.235***	-0.004	0.315***	0.083	0.131
	(0.038)	(0.076)	(0.062)	0.128	(0.115)	(0.113)
Omg.×*Own.*	0.010	0.671***	-0.093	-0.185	-0.136	-0.121
	(0.043)	(0.060)	(0.076)	(0.128)	(0.120)	(0.135)
Optout	-6.866***	-	-5.093***	-19.273***	-1.261**	-6.496***
	(0.208)	-	(0.595)	(0.863)	(0.586)	(0.730)
Log likelihood	-4506.749			-3945.773		
Class Probability			47.5%	26.8%	9.2%	16.6%

Note: Single, double, and triple asterisks (*, **, ***) represent significance at the 10%, 5%, and 1% level.

Table 3.4. Consumer Willingness-to-Pay (95% confidence intervals) for Labeled Egg Attributes

Variable	RPL	LCM-4 Class Model			
		Class 1 *"Attribute Seekers"*	Class 2 *"Price Checkers"*	Class 3 *"Local Supporters"*	Class 4 *"Combination Responders"*
Organic	0.249*	0.821*	0.052	0.048	0.208
	(0.176,0.322)	(0.518,1.125)	(-0.003,0.106)	(-0.341,0.437)	(-0.050,0.466)
Cagefree	0.311*	0.988*	0.085*	-0.278	0.004
	(0.232,0.390)	(0.620,1.356)	(0.038,0.131)	(-0.701,0.144)	(-0.242,0.250)
NoHorm	0.248*	0.628*	-0.069*	0.358	0.374*
	(0.195,0.301)	(0.410,0.845)	(-0.110,-0.027)	(-0.029,0.745)	(0.226,0.522)
Omega	-0.064	-0.098	0.065*	-0.111	0.110
	(-0.153,0.025)	(-0.374,0.178)	(0.001,0.129)	(-0.395,0.172)	(-0.105,0.325)
Ownstate	0.419*	0.866*	0.174*	1.324*	0.548*
	(0.356,0.482)	(0.619,1.113)	(0.133,0.214)	(0.682,1.966)	(0.273,0.824)
Org.×Cag.	0.064	0.139	-0.101*	-0.009	0.332
	(-0.018,0.146)	(-0.126,0.403)	(-0.161,-0.042)	(-0.475,0.457)	(-0.002,0.666)
Org.×NoH.	-0.181*	-0.292	0.143*	-0.316	-0.132
	(-0.265,-0.097)	(-0.600,0.016)	(0.066,0.221)	(-0.675,0.042)	(-0.395,0.131)
Org.×Own.	-0.062	-0.065	-0.091*	0.051	-0.755*
	(-0.150,0.025)	(-0.353,0.223)	(-0.159,-0.023)	(-0.377,0.480)	(-1.137,-0.372)
Cag.×NoH.	0.031	0.261*	-0.033	-0.187	-0.255*
	(-0.033,0.096)	(0.062,0.460)	(-0.082,0.016)	(-0.504,0.130)	(-0.499,-0.010)
Cag.×Own.	0.031	-0.045	0.001	-0.144	0.314*
	(-0.025,0.087)	(-0.224,0.135)	(-0.044,0.046)	(-0.473,0.184)	(0.067,0.560)
NoH.×Own.	-0.037	-0.020	-0.013	-0.001	-0.224*
	(-0.113,0.040)	(-0.270,0.231)	(-0.084,0.057)	(-0.301,0.299)	(-0.438,-0.011)
Omg.×Cag.	0.029	0.204	0.069	0.167	0.609*
	(-0.085,0.144)	(-0.142,0.551)	(-0.022,0.159)	(-0.291,0.624)	(0.193,1.025)
Omg.×NoH.	-0.011	-0.009	0.088*	0.144	0.172
	(-0.097,0.075)	(-0.298,0.280)	(0.019,0.156)	(-0.271,0.559)	(-0.137,0.481)
Omg.×Own.	-0.009	-0.216	-0.052	-0.235	-0.159
	(-0.112,0.094)	(-0.567,0.134)	(-0.122,0.019)	(-0.644,0.173)	(-0.497,0.179)

Note: Single asterisks (*) represent significance at the 5% level.

Table 3.5. Total Willingness-to-Pay (95% Confidence Intervals) for Label Combinations

Variable	RPL	LCM-4 Class Model			
		Class 1	Class 2	Class 3	Class 4
		"Attribute Seekers"	*"Price Checkers"*	*"Local Supporters"*	*"Combination Responders"*
Org.×Cag.	0.624*	1.948*	0.035	0.398	0.543*
	(0.514,0.734)	(1.320,2.575)	(-0.038,0.107)	(-0.145,0.940)	(0.205,0.882)
Org.×NoH.	0.315*	1.157*	0.126*	-0.379	0.449*
	(0.203,0.428)	(0.734,1.580)	(0.011,0.242)	(-1.008,0.250)	(0.062,0.837)
Org.×Own.	0.606*	1.622*	0.134*	1.424*	0.002
	(0.486,0.725)	(1.038,2.206)	(0.049,0.220)	(0.717,2.130)	(-0.363,0.366)
Cag.×NoH.	0.590*	1.876*	-0.017	0.059	0.123
	(0.487,0.693)	(1.272,2.481)	(-0.098,0.064)	(-0.421,0.539)	(-0.170,0.416)
Cag.×Own.	0.761*	1.809*	0.259*	1.538*	0.866*
	(0.657,0.865)	(1.219,2.399)	(0.198,0.321)	(0.832,2.244)	(0.443,1.289)
NoH.×Own.	0.630*	1.474*	0.092	1.212*	0.698*
	(0.521,0.738)	(0.960,1.988)	(-0.001,0.184)	(0.575,1.849)	(0.284,1.112)
Omg.×Cag.	0.276*	1.094*	0.218*	0.247	0.723*
	(0.132,0.420)	(0.603,1.586)	(0.100,0.336)	(-0.414,0.907)	(0.285,1.161)
Omg.×NoH.	0.172*	0.521*	0.084	-0.246	0.657*
	(0.048,0.297)	(0.102,0.940)	(-0.014,0.181)	(-0.873,0.382)	(0.231,1.082)
Omg.×Own.	0.346*	0.552*	0.187*	0.810*	0.500*
	(0.189,0.502)	(0.099,1.004)	(0.078,0.296)	(0.180,1.441)	(0.041,0.958)

Note: Single asterisks (*) represent significance at the 5% level.

Table 3.6. Important Factors for Consumers to Choose Eggs

Factor/Questions[a]	Average Score	Response "Somewhat" or "Extremely" Important
When choosing an egg product, how important are the following factors to you?		
Color of shell	2.89	33.06%
Taste	3.99	75.66%
Nutrient enhancement	2.73	23.52%
Where the product was produced	3.02	36.84%
No additives	3.46	52.47%
How the laying hens are treated	3.21	43.09%
When choosing whether to buy organic eggs or not, how important are the following factors to you?		
Cage-free hens	3.13	39.64%
Use of organic grains for feed	3.24	45.89%
No chemical additives or animal byproducts	3.48	55.43%
When choosing whether to buy cage-free eggs or not, how important are the following factors to you?		
Taste	3.61	62.66%
Health benefits	3.39	52.47%
Trustworthiness of the claim	3.58	59.05%
Animal welfare concerns	3.33	46.05%

[a]The responses were: 1=*not at all important*, 2=*somewhat unimportant*, 3=*neutral*, 4=*somewhat important*, 5=*extremely important.*

Figure 3.1. Example of a Choice Scenario

Please examine the products carefully. If the following 3 egg products were available, what would you do? Your options appear below the table.

Q4	Product A	Product B	Product C
	White; Styrofoam	Brown; Plastic	Brown; Paper
Price	$2.89	$2.09	$2.49
Labels	From another state Organic Cage-Free	From your state Cage-Free Hormone-free	From another state Omega-3

- Buy product A
- Buy product B
- Buy product C
- Not buy any of the three

Chapter 4 - Estimating Demand for Differentiated Products Using Scanner Data

Introduction

In current food markets, consumers' increasing concern about food safety, health benefits, animal welfare, and environmental impact has boosted the demand for differentiated agricultural products, such as organic, nutrient-enhanced, and animal-friendly varieties. Grocery stores have provided consumers with increasingly more product choices differentiated by manufacturer brand, color, size, packaging, and production methods. Studying the demand and price elasticities of differentiated products is critical for examining firms' strategies and impacts on a given product market as well as for improving our understanding of consumer shopping behavior.

Two data sources can be used to examine consumers' preferences and demand for differentiated products: stated and revealed preference data. The advantage of utilizing stated preferences is that hypothetical choices allow for researchers to study products that are not sold in the market (e.g., new products). However, stated preference data have been criticized for their reliability, since respondents could make different purchasing decisions in reality from their stated choices in hypothetical settings. Also, many influential factors, such as budget constraints and store discounts, are generally ignored in choice experiments, which could cause an upward bias of estimated demand. As an alternative, revealed preferences, such as scanner data, reflect consumers' real purchased choices in the markets and are able to capture consumers' dynamic behavior by recording their purchases over time (Swait and Andrew, 2003; Chang, Lusk, and Norwood, 2010).

A major problem with estimating demand for differentiated products using real market data is the econometric dimensionality problem. The number of parameters to be estimated increases exponentially as the number of alternative products increases. Traditional demand approaches that use the product-space concept, such as Almost Ideal Demand System (AIDS) and Rotterdam models, attempt to solve the dimensionality problem by aggregating products (e.g., Lusk, 2010; Baltzer, 2004) or using multi-stage budgeting to group products into a reduced number of categories (e.g., Hausman, Leonar, and Zona, 1994). However, both methods impose prior groupings and assumptions on product relationships within categories. Another issue with traditional demand methods is the use of a "representative" consumer, which assume consumers have homogeneous preference (Lianos and Genakos, 2012). Previous studies have shown that consumers have heterogeneous preferences using both stated and revealed preferences (e.g., Gracia, A., J. Barreiro-Hurle and B. Lopez-Galan, 2014; Lopez and Lopez, 2009). An alternative method could be the distance metric approach (Pofahl and Richards, 2009), which is capable of dealing with differentiated food categories available in scanner data, but this approach requires some continuous attributes (e.g., fat and alcohol content) of products.

A flexible model that claims to overcome the shortcomings of the traditional demand models is a random coefficient logit model developed by Berry, Levinsohn, and Pakes (1995; henceforth BLP). The BLP model uses the attribute-space concept to address the dimensionality problem and allows for flexible substitution patterns without a priori product grouping. In addition, the BLP model is able to account for potential endogeneity of product prices. "A Practitioners' Guide" for the BLP implementation has been authored by Nevo (2000b), and his demand-side code, which has been made available online for public has been heavily cited. In this paper, the BLP model is applied to the case of differentiated eggs to study the substitution

patterns between conventional and specialty products, as well as those among different specialty eggs.

According to the American Eggs Board (2015), there were 175 egg producers with at least 75,000 hens or more by December, 2015, compared with 235 in 2008; and 66 egg producers with at least 1 million laying hens and 17 that own more than 5 million hens at the end of 2015, compared with 63 and 15 in 2008, respectively. As many consumers reply on eggs as a relative cheap sources of protein and minerals, 93% households in the U.S. are reported to purchase eggs (American Eggs Board, 2008). The annual consumption of eggs in the U.S. has been stable at approximately 250 eggs per person since late 1990s (American Eggs Board, 2015). The egg market is also representative of differentiated food products. To meet consumer's specific demands, many egg producers have differentiated their products by advertising attributes related to health benefits, such as vitamin E and omega-3 enriched, animal welfare attributes, such as cage-free and free-range, and production practices, such as organic and vegetarian-fed (Allender and Richards, 2010). The production of specialty eggs has increased steadily and accounted for nearly 16% of the entire egg market in 2005 (Chang, Lusk, and Norwood, 2010). The sales of organic, omega-3 and vegetarian eggs contributed 5.6% of the industry revenue in 2013, while cage-free eggs accounted for 4.3% (IBISWorld, 2014).

The objective of this study is to estimate demand relationships in the U.S. differentiated egg market using scanner data. A BLP random coefficient logit model was used to overcome the potential dimensionality problem and account for consumer heterogeneity. Product-level scanner data on U.S. egg sales are available for two years and provides a good opportunity to examine demand for differentiated products and price competition. This dataset includes over 2,000 individual products under national or private labels, differentiated by egg size, package size,

shell color, and labeled attributes, such as organic, omega-3, and vitamin-enriched. Information on consumer characteristics (household income and number of children under 18 years old) were used to model heterogeneity in consumers' tastes. Although we do not directly observe consumer characteristics from the dataset, we estimated the distribution of the demographics based on the Current Population Survey. The estimated parameters were used to calculate own- and cross-price elasticities at the product level. Under the assumption of a Bertrand-Nash equilibrium, the first-order condition of the profit maximization problem will yield the markup, which can be further used to calculate the marginal cost and percentage margin. The findings from this study can be compared with previous studies on demand for differentiated eggs using regional and household-level scanner data.

Our results show that average consumers exhibit an overall preference for nutrient-enhanced and brown shell eggs. Higher earning households prefer organic and brown shell varieties more than their counterpart, while those with more children tend to prefer conventional products compared with their peers. Demand for conventional and private labeled eggs are less elastic, which would lead to lower margins for specialty and manufacturer branded eggs. Our result is consistent with previous findings that basic products are associated with greatest price-cost margins (e.g., Chidmi and Lopez, 2007).

Literature Review

As egg products have become increasingly differentiated through advertised attributes related to production approaches, nutrient-enrichment, environmental issue, and animal welfare, several studies have offered insights into consumer preferences and demand for differentiated eggs. Based on stated preference surveys, Asselin (2005) used a national survey and reported that Canadian consumers with higher health consciousness were willing to pay a higher premium for

omega-3 eggs; Heng, Peterson, and Li (2013) found that most subjects in their U.S. study were willing to pay a positive premium for organic eggs as well as for eggs produced under animal welfare friendly environment. Gracia, A., J. Barreiro-Hurle and B. Lopez-Galan (2014) reported that the majority of respondents in their Spanish survey preferred local egg products and value the combination of organic and local claims. Using product level scanner data in three major cities, Lusk (2010) estimated an AIDS model to examine the effect of Proposition 2 in California and found that demand for cage-free and organic eggs increased over time in San Francisco and Oakland, while demand in Dallas was unchanged. Chang, Lusk, and Norwood (2010) used retail scanner data from two regional markets and estimated a hedonic pricing model. They found that average consumers valued cage-free, organic, and omega-3 eggs, but the observed premium for cage-free eggs was attributed to shell color. Allender and Richards (2010) applied a random parameter logit (RPL) model to a household-level scanner data and investigated the impact of animal welfare legislation on consumer welfare in California. Their results suggested that the majority of California households would not buy cage-free eggs and such higher production costs would result in net consumer welfare loss. Baltzer (2004) estimated an AIDS model using scanner data on weekly egg sales in Denmark and found that consumers were willing to pay a high premium for organic and barn eggs, but a small premium for pasteurized eggs.

The review of the literature reveals that when a product level scanner data is available, most studies on differentiated products have selected either a demand system approach or a hedonic pricing model. However, both approaches have some limitations. As mentioned earlier, traditional demand system approach assumes homogeneous consumer preferences and might face dimensionality problem. Lusk (2010) and Baltzer (2004) alleviated such problem by aggregating individual egg products into four and five categories, respectively, yet such prior

groupings are mostly subjective and may yield inconsistent results due to researchers' different opinions on grouping. Hedonic models address the dimensionality issue using the attribute-space (Lancaster, 1966; Rosen, 1974), but assumes perfect competition and that all product characteristics can be observed (Bajari and Benkard, 2005).

The BLP model introduced by Berry, Levinsohn, and Pakes (1995) does not require prior grouping and allows for flexible substitution patterns that depend on product attributes and consumer characteristics. In a BLP model, we expect consumers to not only substitute among products with similar characteristics, but also to rank products similarly with people with like demographics. Compared with the RPL model proposed by McFadden and Train (2000), the BLP is able to estimate with market level data rather than individual level data (Imbens and Wooldridge, 2007). The BLP model has been applied to various markets including automobiles (Berry, Levinsohn, and Pakes, 1995), breakfast cereals (Nevo, 2000a, 2001), milk (Lopez and Lopez, 2009), and yogurt (Villas-Boas, 2007). Our study is the first application of the BLP model to study differentiated egg products.

The Model

In a BLP random coefficient logit model, consumers are assumed to purchase the product that gives them the highest utility. The indirect utility of consumer *i* of choosing product *j* can be specified as:

$$U_{ij} = \boldsymbol{x_j \beta_i} - \alpha_i p_j + \xi_j + \varepsilon_{ij} \tag{4.1}$$

where x_j, p_j, and ξ_j are observed product characteristics, product price, and unobserved product characteristics, respectively; β_i and α_i are parameters that represent individual taste and marginal utility of price, and ε_{ij} represents a random component across consumers and choices.

The individual-specific parameters β_i and α_i can be decomposed into a mean value, a taste component varied with observed demographics, and a taste component varied with unobserved consumer characteristics as:

$$\begin{pmatrix} \alpha_i \\ \boldsymbol{\beta_i} \end{pmatrix} = \begin{pmatrix} \alpha \\ \boldsymbol{\beta} \end{pmatrix} + \boldsymbol{\Gamma D_i} + \boldsymbol{\Sigma \nu_i} \tag{4.2}$$

where $\begin{pmatrix} \alpha \\ \boldsymbol{\beta} \end{pmatrix}$ capture the mean levels, $\boldsymbol{D_i}$ is a vector of demographic variables with a distribution from other data sources, $\boldsymbol{\nu_i}$ is a vector that capture unobserved consumer characteristics that is usually assumed to follow a normal distribution. $\boldsymbol{\Gamma}$ and $\boldsymbol{\Sigma}$ are matrices of parameters that measure the taste varying with demographics and unobserved characteristics. Now, the mean utility level (δ_{ij}) can be expressed as:

$$\delta_{ij} = \boldsymbol{x_j \beta} - \alpha\, p_j + \xi_j \tag{4.3}$$

The demand system is completed with an outside good, which represents consumers' options outside of the dataset. For an outside good, the mean level of utility,δ_0, is normalized to equal zero.

If we let $\boldsymbol{\theta} = (\boldsymbol{\theta_1}, \boldsymbol{\theta_2})$ be a vector of all the parameters of the model. The vector $\boldsymbol{\theta_1} = (\alpha, \boldsymbol{\beta})$ contains the linear parameters, and $\boldsymbol{\theta_2} = (\boldsymbol{\Gamma}, \boldsymbol{\Sigma})$ is a vector of non-linear parameters. The variation from the interaction of consumer *i*'s characteristics and product *j*'s attributes can be captured by:

$$\mu_{ij}(\boldsymbol{x_j}, p_j, \boldsymbol{D_i}, \boldsymbol{\nu_i}; \boldsymbol{\theta_2}) = \left(-p_j, \boldsymbol{x_j}\right)(\boldsymbol{\Gamma D_i} + \boldsymbol{\Sigma \nu_i}) \tag{4.4}$$

Combining equation (4.3) and equation (4.4), the indirect utility function can now be written as a summation of three terms:

$$U_{ij} = \delta_{ij} + \mu_{ij} + \varepsilon_{ij} \tag{4.5}$$

where $\mu_{ij} + \varepsilon_{ij}$ represent a deviation from the mean utility with a zero mean.

If an individual who chooses product j can be defined by a vector of consumer characteristics and product-specific shocks such that:

$$A_j(\boldsymbol{x}, p, \delta; \boldsymbol{\theta_2}) = \{(\boldsymbol{D_i}, \boldsymbol{\nu_i}, \varepsilon_{i0}, \dots \varepsilon_{iJ}) | U_{ij} \geq U_{il} \ \ \forall l = 0,1, \dots, J\}, \tag{4.6}$$

then, the predicted market share of product j is an integral over the mass of consumers in the region A_j, which can be expressed as:

$$s_j(\boldsymbol{x}, p, \delta; \boldsymbol{\theta_2}) = \int_{A_j} d\boldsymbol{F}(\boldsymbol{D}, \boldsymbol{\upsilon}, \boldsymbol{\varepsilon}) = \int_{A_j} d\boldsymbol{F}(\boldsymbol{D}) d\boldsymbol{F}(\boldsymbol{\nu}) d\boldsymbol{F}(\boldsymbol{\varepsilon}) \tag{4.7}$$

Assuming that ε_{ij} is an iid error with an extreme value type I density, the equation (4.7) becomes:

$$s_j(\boldsymbol{x}, p, \delta; \boldsymbol{\theta_2}) = \int_{A_j} \frac{e^{\delta_{ij}+\mu_{ij}}}{1+\sum e^{\delta_{il}+\mu_{il}}} d\boldsymbol{F}(\boldsymbol{D}) d\boldsymbol{F}(\boldsymbol{\nu}). \tag{4.8}$$

The demand elasticity for product j with respect to the price change of product k is defined as:

$$\eta_{jk} = \frac{ds_j}{dp_k}\frac{p_k}{s_j} = \begin{cases} -\frac{p_j}{s_j}\int \alpha_i s_{ij}(1 - s_{ij}) d\boldsymbol{P}(\boldsymbol{D}) d\boldsymbol{P}(\boldsymbol{\nu}) \ \ if\ j = k \\ \frac{p_j}{s_j}\int \alpha_i s_{ij} s_{ik} d\boldsymbol{P}(\boldsymbol{D}) d\boldsymbol{P}(\boldsymbol{\nu}) \ \ otherise \end{cases} \tag{4.9}$$

where $s_{ij} = \frac{e^{\delta_{ij}+\mu_{ij}}}{1+\sum e^{\delta_{il}+\mu_{il}}}$ is the probability of individual i purchasing product j.

With respect to the supply side, following Nevo (2010a), we assume that there are F multi-product producers, and each of them produces some subset J_f of the J products. They choose the range of prices for the J_f differentiated products to maximize total profits, that is:

$$\Pi_f = \sum_{j \in J_f} (p_j - c_j) s_j M \tag{4.10}$$

where p_j is product j's price, c_j is the marginal cost, s_j is the market share, and $M$is the number of consumers in the market. Under the assumption of Bertrand-Nash equilibrium, the first-order condition for product j is given by:

$$s_j + \sum_{k \in J_f} (p_k - c_k) \frac{\partial s_k}{\partial p_j} = 0 \tag{4.11}$$

In vector notation, the first-order condition for J_f products can be rewritten as:

$$s(p) + \mathbf{\Omega}(p - mc) = 0 \tag{4.12}$$

where $\mathbf{\Omega}$ is the ownership matrix, and $\Omega(j,k)$ = 1 if product j and k are sold by the same firm and $\Omega(j,k)$ = 0, otherwise; mc is a vector of marginal costs. Thus, the price-cost markup can be recovered as $p - mc = -\mathbf{\Omega}^{-1}s(p)$, and the marginal cost and percentage margin ($\frac{p-mc}{p}$) can also be computed.

Nevo (2001) suggested that the margins can come from three sources depending on industry structure. The first structure consists of single-product firms, and the margin is due to product differentiation; the second structure consists of multi-product firms, and the margin is due to multi-product firm pricing; and the final structure consists of joint ownership of all products, and the margin is due to monopoly or potential price collusion. In this study, we calculated margins under the second structure but also reported the mean margins for all three hypothetical structures to examine the differences among different scenarios.

Data and Estimation

Egg sales and consumer characteristics are the two sets of data used for this empirical demand estimation. The egg weekly sales, volume sold, and characteristics are provided by Nielson. The data covers over 300 brands (including national and private brands) encompassing 2,287 products nationwide from April, 2008 to March, 2010. Observed product characteristics include brand name, egg size, package size, shell color, and labeled attributes, such as organic and nutrient-enhanced (e.g., omega-3 and vitamin-added).

Since consumer characteristics and instrumental variables are reported monthly, the weekly egg sales and volumes sold were aggregated into 23 months, and each month was treated as a market. Retail prices were computed by dividing the dollar sales of each product by its

volume sold. Actual market shares for each product were computed as a ratio of quantities of product sold to the potential market size. Following Nevo (2000), the potential market was defined as a product of U.S. per capita egg consumption (American Eggs Board, 2015) and the size of U.S. total population during each period (U.S. Census Bureau, 2015), divided by 12 as monthly observations. Thus, the outside good is defined as the part of the potential market that is not included in the sample. As the main interest of this study is to examine the demand of specialty egg products, we define egg products as combinations of manufacturer brand, shell color, organic production, and health benefits, including omega-3 and vitamin-added. Since there are a large number of individual products available in the egg market, we only focused on products in dozen cartons (including 1,560 products) and aggregated different size eggs into one size. We finally selected the 25 most popular products based on such classification and market share, and these products accounted for up to 19% of the potential market during the 23 months of the sample period, while the original data represented up to 23% of the potential market.

Monthly information on consumer characteristics (household income and number of children under 18 years old) was obtained from the Current Population Survey (U.S. Bureau of the Census). We allow for monthly variation in demographics to enhance identification (Hovhannisyan and Bozic, 2014). For each month, characteristics of 200 individuals were randomly drawn to match the egg purchases in the market. Unobservable characteristics were generated from a normal distribution. In sum, our dataset consists of 23 markets, and each market has 25 product and 200 consumers. Stacking the markets generated 575 (23×25) products and 4,600 (23×200) consumer observations.

As Berry (1994) and Nevo (2001) suggested, since the model distinguishes observed and unobserved product characteristics, prices could be correlated with the unobserved

characteristics if they impact consumers' choices. Thus, we followed Nevo (2001) and introduced brand-specific dummies into demand estimation, which captures product characteristics that do not vary with individual tastes and can be treated as fixed brand effects.

The instrumental variables address the potential price endogenous problem. Following Villas-Boas (2007) and Lopez and Lopez (2009), instrumental variables included the interactions of 25 brand dummies with input prices (prices of corn and soybean used for feed, and electricity), which in total resulted in 75 instrumental variables. The monthly U.S. average prices of corn and soybeans were obtained from the Feed Grains Database (U.S. Department of Agriculture, 2014). The monthly electricity price was represented by the U.S. Consumer Price Index (CPI) for electricity (Bureau of Labor Statistics, 2014).

The parameters were estimated using the generalized method of moments (GMM). This procedure minimizes an objective function formed by the implied error term and instruments. The error term is computed by inverting the market share function in equation (4.8) to solve for the mean utility level δ in each market that equates the observed market shares to the predicted market shares, given values of the nonlinear parameters $\boldsymbol{\theta_2}$. Then the error term is defined as the difference between this mean utility and the one predicted by the linear parameters α and $\boldsymbol{\beta}$.

Results

Estimated results for the BLP model are reported in Table 4.1, and the MATLAB codes used for estimation can be found in the Appendix. The taste parameters for mean utility (β), retrieved from the minimum-distance procedure (Chamberlain, 1982), are displayed, as well the deviations from the mean depending on unobserved (v) and observed consumer characteristics (D), including household income and number of children under 18 years old, in adjacent columns. As expected, the coefficient for price is negative and statistically significant, implying

that higher prices reduce utility for consumers. Households with higher income would bear higher prices, while those with more children were more price sensitive. Average consumers also showed preference for nutrient-added and brown-shell eggs, while organic eggs were disvalued by an average consumer. Regarding taste heterogeneity, the higher income households had greater preferences for organic and brown-shell eggs, yet households with more children had lower preference for specialty eggs. Such results could indicate that family with larger size would prefer conventional eggs, given their budget for purchasing eggs.

Following equation (4.9), own- and cross- price elasticities at the product level were computed to examine the demand substitution patterns among egg products. There are a total of 625 own- and cross-prices elasticities (25×25) for 25 products in each market, and Table 4.2 presents median price elasticities for selected 15 products from 23 markets. These selected products involve private and national labels, conventional and specialty egg products. In the Table, the conventional products were displayed in the left section, and the specialty eggs were displayed in the right section. Within each section, private labeled eggs were shown first and followed by national branded eggs. Following Tonsor and Marsh (2007), a Krinsky-Robb bootstrapping procedure was conducted to evaluate whether each estimated elasticity was different from zero. Based on estimated coefficients and variance, we used 1,000 random draws from a multivariate normal distribution to simulated series of elasticities in MATLAB, the proportion of simulated elasticities with values greater/smaller than zero represents the p-value associated with the one-sided test. The test results suggested that all estimated elasticites were statistically different from zero at 1% level. [5]

[5] The MATLAB codes for simulating elasticites can be found in Appendix.

As expected, all own-price elasticities were negative, varying from -0.95 to -5.25. In general, specialty eggs had higher own-price elasticities in absolute value compared with conventional eggs, suggesting consumers were more price sensitive to their price changes. For example, within products with a private label, the own-price elasticity for conventional eggs was -0.95, while the own-price elasticities for specialty eggs ranged from -2.17 to -4.75. Demand for more expensive specialty eggs tended to be more elastic, and the own-price elasticity for organic egg products with brown shell was the greatest in magnitude. Also, comparing the own-price elasticities across egg products that share common attributes, we see that demand for private-label products (both conventional and specialty eggs) were less elastic, which indicates shoppers that buy private-labels are less responsive to price changes.

Such results are consistent with previous findings regarding private label (Cotterill and Samson, 2002; Lopez and Lopez, 2009), and this might because that private labeled products are almost always cheaper, as Cotterill and Samson (2002) claimed. The smaller values from our estimation fall within the previously estimated ranges of egg demand elasticities obtained using different data and approaches. Allender and Richards (2010) reported own-price elasticities for individual egg products ranging between -0.44 and -1.55. Lusk (2006) estimated elasticities of demand for four aggregated egg products in San Francisco/Oakland and Dallas/ Ft. Worth; his reported own-price elasticities ranged from -0.07 for conventional eggs to -2.98 for cage-free eggs. Baltzer (2004) reported the own-price elasticities for five aggregated egg products in Danmark, ranging between -1.30 for pasteurized eggs and -2.16 for free-range eggs.

Table 4.2 also presents the cross-price elasticities. The values differed across brands and specialties, ranging from 0.00 to 1.20. The cross-price elasticity η_{jk} in row *j* column *k* indicates the demand elasticity for product *j* with respect to the price change of product *k*. Product 1-6 are

conventional eggs, and products 7-15 are specialty eggs. There are more substitutions within the same category: among conventional eggs or among specialty egg products. Moreover, within the specialty egg category, consumers appear to substitute within varieties with similar attributes. For example, when the price of brown-shell eggs increases, under either private brand or national brand, some consumers substituted with other brown-shell eggs under different brands, while others would substitute with organic or nutrient-added eggs with brown shell. Similarly, when organic or nutrient-added eggs with brown-shell became more expensive, consumers would substitute with other brown-shell varieties, including organic eggs with brown shell, nutrient-added eggs with brown-shell, and brown-shell eggs. Such results may suggest that average consumers in our data seek out brown shell, perhaps as a signal of higher health benefit since functional eggs are usually with brown shell in stores. In contrast, if the price of nutrient-added eggs with white shell increases, there are only limited substitutions occurring among other specialty eggs. Together, our results suggest that consumers of eggs with brown shell perceive shell color as an important feature of their choices and value brown shell robustly. Such results are consistent with previous findings using scanner data that premiums for some specialty eggs were attributed to shell color (e.g. Chang, Lusk and Norwood, 2010).

Using the estimated results from the BLP model, price-cost markups were recovered by assuming a Nash-Bertrand equilibrium, and marginal costs and percentage margin can be further calculated using equation (4.12). Table 4.3 provides the product level estimated marginal costs for selected products and percentage margin, which is also referred to as the Lerner index. Results show that private labeled egg products and conventional egg variety yielded relative high markups compared with manufacturer branded and specialty eggs, respectively. The mean margin for conventional eggs ranged between 47% and 80%, which is nearly twice the range and

magnitude for specialty eggs (between 21% and 49%). For conventional eggs, the mean margin for private labeled eggs was 80%, while the highest mean margin for manufacturer branded products was 54%. Within the specialty egg category, private labeled products also had greater margins than manufacturer branded eggs. For example, private labeled brown shell and nutrient-added eggs yielded nearly twice and three times margins as other branded brown shell and nutrient-add eggs, respectively. This reflects more elastic demand for manufacturer branded and specialty products. Such results are consistent with previous finding that basic types of products had higher markups (Chidmi and Lopez, 2007; Lopez and Lopez, 2009).

The magnitude of margin were quite large for some private labeled, especially for private labeled conventional eggs (80% margin). We do not have a clear interpretation for this. But as Mintel (2011) reported, the private labeled eggs have dominated the market, accounting for 64.1% of sales. Thus, private labeling constitutes an important strategy in egg retailing, which is beyond the scope of this study. Also, our estimates does not account for fixed cost, which usually plays an important role in egg production.

Mean percentage price-cost margins for three hypothetical industry structures are displayed in Table 4.4. The structure that best fits the egg market can be identified if existing margins in the industry can be observed. Alternatively, we can conduct a non-nested test. The test details are described in Gayle and Brown (2015). Markups under alternative industry structures are calculated and then used to estimate supply equations along with marginal costs. The error terms associated with these supply equations are used to conduct a non-nested statistical test, which is a modification of the likelihood ratio test. The test statistics is distributed standard normal, with critical values for a one-sided test at the 10% level of approximately

±1.29. The test statistics were computed to be very close to zero, failing to reject the null that one alternative structure was more fitting than the other.[6]

Conclusion

This study applied a random coefficient logit (BLP) model to estimate the demand for the egg industry. Our results show that average consumers valued nutrient-added and brown-shell eggs. Households with higher income preferred organic and brown-shell eggs more than others, while those with more children under 18 years old would prefer conventional eggs that are less expensive. Demand for conventional and private label eggs were estimated to be less own-price elastic. The substitution patterns among brown shell eggs and other health-related eggs with brown shell, including organic as well as nutrient-enhanced eggs, suggest consumers regard brown shells as a distinctly preferred feature.

Specialty and manufacturer brand eggs yielded lower margins due to higher demand elasticities. Such results suggest that although specialty eggs are usually sold at higher prices, greater own-price elasticities and lower margin may cause market share losses for specialty eggs suppliers when prices rise, usually due to higher input prices. In contrast, demand for cheaper private labeled eggs is relative stable, and suppliers are able to earn higher margins. Some consumers do value certain specialty eggs, but suppliers should be aware of what high demand elasticities and low margins for specialty products imply.

The BLP model does not come without limitations. Such model requires a large number of observations and much computing power (Rasmusen, 2007), and the estimates might be sensitive to various optimal algorithms and starting values (Knittel and Metaxoglou, 2012). To

[6] The Stata codes used for the test can be found in Appendix.

gauge robustness of the current findings, the model was estimated several times using partial observations by randomly dropping one market at a time. Indeed, results were sensitive to various selected observations. Since the main concern of traditional demand approaches is the prior product grouping, future studies could examine how sensitive the estimates from demand approaches would be subject to various prior groupings. The comparisons of different approaches based on out-of-sample prediction performances are encouraged.

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Table 4.1. Estimated Results for Demand Parameters (Standard Error)

Variable	Means (β)	Unobserved Demographics (v)	Interactions with Demographic Variables (D): Household Income	Interactions with Demographic Variables (D): Number of Child under 18 Years Old
Price	-1.346***	-0.080***	0.675***	-1.246***
	(0.209)	(0.000)	(0.028)	(0.021)
Organic	-4.796***	-0.088***	10.116***	-3.072***
	(0.219)	(0.002)	(0.780)	(0.163)
Nutrient-added	0.688***	0.203*	1.519	-1.094
	(0.173)	(0.104)	(3.241)	(1.734)
Brown-shell	0.771**	-1.747***	22.044***	-0.890***
	(0.327)	(0.004)	(0.768)	(0.089)
Constant	-2.496***	0.111***	-3.225***	3.618***
	(0.180)	(0.004)	(0.039)	(0.029)
GMM objective: 9.718				
χ^2Stat: 7535987				

Note: Standard errors are given in parentheses. *, **, and *** represent 10%, 5%, and 1% significant level, respectively.

Table 4.2. Own- and Cross-Price Elasticities for Selected Egg Products

	Conventional Eggs						Specialty Eggs								
Br.	Private	Cal-Maine	Happy Hen	Hillan-dale	Rose Acre	Sauder's	Private	Private	Private	Land O' Lakes	4 Grain	4 Grain	Eggland Best	Eggland Best	Eggland Best
Att.	Conv	Conv	Conv	Conv	Conv	Conv	Bro	Bro,Org	Bro,Nut	Bro	Bro	Nut	Nut	Bro,Nut	Bro,Org
#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-0.953*	0.001*	0.002*	0.012*	0.042*	0.005*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.008*	0.000*	0.000*
2	1.183*	-1.888*	0.002*	0.012*	0.042*	0.005*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.008*	0.000*	0.000*
3	1.192*	0.002*	-1.973*	0.013*	0.044*	0.005*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.006*	0.000*	0.000*
4	1.156*	0.002*	0.002*	-2.082*	0.043*	0.005*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.008*	0.000*	0.000*
5	1.199*	0.002*	0.002*	0.013*	-1.901*	0.005*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.008*	0.000*	0.000*
6	1.157*	0.001*	0.002*	0.012*	0.042*	-2.129*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.009*	0.000*	0.000*
7	0.003*	0.000*	0.000*	0.000*	0.000*	0.000*	-2.166*	0.126*	0.018*	0.089*	0.041*	0.000*	0.029*	0.143*	0.057*
8	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.357*	-4.753*	0.018*	0.163*	0.049*	0.000*	0.048*	0.343*	0.145*
9	0.002*	0.000*	0.000*	0.000*	0.000*	0.000*	0.473*	0.217*	-2.221*	0.127*	0.045*	0.000*	0.036*	0.225*	0.098*
10	0.001*	0.000*	0.000*	0.000*	0.000*	0.000*	0.394*	0.286*	0.018*	-4.005*	0.046*	0.000*	0.040*	0.277*	0.124*
11	0.002*	0.000*	0.000*	0.000*	0.000*	0.000*	0.477*	0.237*	0.018*	0.135*	-3.450*	0.000*	0.037*	0.247*	0.106*
12	0.091*	0.000*	0.000*	0.001*	0.003*	0.000*	0.010*	0.005*	0.000*	0.003*	0.001*	-3.090*	0.054*	0.005*	0.002*
13	0.046*	0.000*	0.000*	0.000*	0.002*	0.000*	0.014*	0.009*	0.001*	0.004*	0.002*	0.001*	-3.695*	0.009*	0.004*
14	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.358*	0.320*	0.019*	0.155*	0.047*	0.000*	0.044*	-4.318*	0.147*
15	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.357*	0.325*	0.018*	0.163*	0.048*	0.000*	0.048*	0.343*	-5.254*

Note: * represents elasticities statistically different from 0 at 1% level.

Table 4.3. Recovered Mean Marginal Costs and Margins

	Brand Name	Attributes	Price	MC	Margin (%)	Range of Margin (%)[a]
Conventional Eggs	Private	Conventional	1.571	0.316	80.325	(98.469,62.181)
	Cal-Main	Conventional	1.414	0.662	50.710	(56.346,45.073)
	Happy Hen	Conventional	1.477	0.728	54.232	(63.052,45.413)
	Hillandale	Conventional	1.547	0.804	51.222	(58.349,44.094)
	Rose Acre	Conventional	1.461	0.690	54.055	(62.165,45.945)
	Sauder's	Conventional	1.576	0.840	49.996	(57.284,42.709)
Specialty Eggs	Private	Brown	2.064	1.027	52.545	(61.874,43.216)
	Private	Brown, Organic	3.824	2.857	25.665	(28.076,23.254)
	Private	Brown, Nutrient	1.679	0.643	60.431	(65.462,55.399)
	Land O Lakes	Brown	3.122	2.358	24.953	(25.918,23.988)
	4 Grain	Brown	2.583	1.829	29.188	(30.425,27.951)
	4 Grain	Nutrient	2.317	1.566	31.746	(32.990,30.501)
	Eggland's Best	Nutrient	2.793	2.036	27.481	(28.326,26.635)
	Eggland's Best	Brown, Nutrient	3.472	2.624	24.342	(25.381,23.303)
	Eggland's Best	Brown, Organic	4.023	3.175	21.120	(22.071,20.169)

[a]The range is calculated as plus/minus 1 standard deviation around the mean.

Table 4.4. Computed Mean Percentage Margins for Three Hypothetical Structures

Hypothetical Industry Structure	Margins (%)
Single Product Firms	45.75
Multi-Product Firms	48.42
Joint Ownership of All Products Considered	79.30

Chapter 5 - Summary

Consumers increasingly demand more information about how their food is produced and are interested in agricultural products differentiated by nutrient contents, production practices, origins, and living conditions of farm animals. This dissertation consisted of three analyses on the differentiated egg market. The three components of this study were to assess consumers' attitude and valuation for various hen-welfare related practices, examine consumers' responses to multiple product labels accounting for interaction effects, and study demand relationship and price competition using scanner data.

The first study contributes to the literature by focusing on two unaddressed questions: how consumer perceive and value various animal-welfare related managing practices, and how consumers respond to the trade-off between animal welfare and potential environmental impacts. Four management practices regarding hen's welfare were considered in the study, including usage of cage, outdoor access, induced molting, and stocking density. While all considered practices were valued by respondents, the cage-free system gained the highest average premium. Such results indicate a potentially profitable opportunity for producers to switch to non-cage systems and economic incentives for producers to adopt other animal-welfare friendly practices if the estimated premium exceeds their costs. Regarding the second question, the results indicate that consumers currently place more weight on animal welfare issues than potential environmental issues in their selection of egg products.

Consumers commonly use labels to identify products with preferred attributes, and many food products are affixed with various labels in the market. The second essay found that consumers' preferences were heterogeneous and can be categorized into four classes, and their preference differed in type of attributes, combination of labels, and across classes. This study

contributed to literature by not only investigating various attribute categories, including health, animal-welfare, origin, and additives, but also potential substitution/complementary effects between labels, especially between animal-welfare and other claims. And to my knowledge, this work is the first to study redundant labeling issues. Results show that locally produced label was valued by all four classes, indicating consumer's strong preference for local food. Over half of the respondents valued the hormone-free claim, a redundant label, which could be a result of consumers' general concern over additives. Label combinations were found to affect certain consumer segments, and the substitution/complementary effects could be sizable to offset main premiums associated with individual attributes. Thus, producers should take these information into account for the most effective labeling strategies. .

Scanner data have become a popular medium in consumer demand analysis, yet traditional demand approaches have some limitations in examining demand for differentiated products. A relative new approach, the BLP random coefficient logit model, was applied in the third essay to overcome the shortcomings of traditional approaches used in existing studies. This study is the first attempt to apply a BLP model to the differentiated egg market. The results show that average consumers exhibited an overall preference for nutrient-added and brown shell eggs. However, suppliers need to be cautious about producing specialty varieties, since the demand for specialties were found to be highly elastic, which would lead to lower margins. Such results suggest that although specialty products are generally charged higher prices, producers would still incur profit loss from price variation. On the other hand, demand for conventional and private labeled eggs that are priced consistently at low levels were found to be less elastic, allowing producers to capture higher margins.

Recognizing the limitations of this study provides suggested directions for future studies. Results from Essays 1 and 2 are potentially subject to hypothetical bias similar to other stated preference methods, and the estimated WTP should be interpreted cautiously. Also, respondents in Essays 1 and 2 were assumed to be fully informed through the statement before the choice experiments. Future studies should include questions or use a split sample approach to test if respondents were truly aware of all the information. Essay 2 did not identify the characteristics of different consumer segments. Future studies could be designed to identify the characteristics for various segments to provide recommendations to target specific consumer segments. Additionally, the estimates from the BLP model could be sensitive to various optimal algorithms, starting values, and selected observations. Future studies should examine how sensitive the estimates from traditional demand systems are to various prior grouping, and comparisons of different approaches based on out-of-sample predictions are encouraged.

Appendix A- MATLAB Codes for the BLP Model Estimation

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%Scanner Data BLP Model Based on Nevo%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
clear all

% load data
load data0312

%generate v matrix, #row=nmkt=23, #column=ns*#column of x2 then save it to
dataset%
%v=randn([23,1000]);

global invA ns x1 x2 s_jt IV vfull dfull theta1 theta2 theti thetj cdid
cdindex

s_jt=mkts; %sj calcualted by per capital consumption*total population
p=data(:,4);

%x1:price and 24 bran dummy variables%
x1=[p data(:,12:36)];

%x2: constant, price, attribute dummies: org nut bro%
%heterogeneity associated with demographics
x2=[data(:,2) p data(:,7:8) data(:,10)];

demogr=[stdemo(:,2:201) stdemo(:,502:701)]; %standardized demo income and
#kids

IV=[data(:,37:111) x1(:,2:26)]; %iv

id=[data(:,1)];

ns = 200;       % number of simulated "indviduals" per market %
nmkt = 23;     % number of markets %
nbrn = 25;     % number of brands per market.

% this vector relates each observation to the market it is in %
cdid = kron([1:nmkt]',ones(nbrn,1));
% this vector provides for each index the of the last observation %
% in the data used here all brands appear in all markets. if this %
% is not the case the two vectors, cdid and cdindex, have to be   %
% created in a different fashion but the rest of the program works fine.%
cdindex = [nbrn:nbrn:nbrn*nmkt]';
```

```
% starting values. zero elements in the following matrix correspond to %
% coeff that will not be max over,i.e are fixed at zero. %

theta2w=    [-.8         0.2          0.5  ;
             -.6         3.01        1.7;
             .7         1.6         -1.5 ;
             1.2         1.9         1.39    ;
             .6          1.8         -1.5   ];


% create a vector of the non-zero elements in the above matrix, and the %
% corresponding row and column indices. this facilitates passing values %
% to the functions below. %
[theti, thetj, theta2]=find(theta2w);

horz=['mean       sigma      inc     child'];
vert=['constant  ';
      'price     ';
        'org       ';
         'nut       ';
          'bro       '];

% create weight matrix
invA = inv([IV'*IV]);

% Logit results and save the mean utility as initial values for the search
below

% compute the outside good market share by market
temp = cumsum(s_jt);
sum1 = temp(cdindex,:);
sum1(2:size(sum1,1),:) = diff(sum1);
outshr = 1.0 - sum1(cdid,:);

y = log(s_jt) - log(outshr);
mid = x1'*IV*invA*IV';
t = inv(mid*x1)*mid*y; % IV of log shares on X1 using IV as instruments
mvalold = x1*t;        % Fitted log shares
oldt2 = zeros(size(theta2)); % Zero out old theta2
mvalold = exp(mvalold);  % Compute shares

save mvalold mvalold oldt2
clear mid y outshr t oldt2 mvalold temp sum1

vfull = v(cdid,:);
dfull = demogr(cdid,:);

tic % Start stopwatch

% the following line computes the estimates using a Quasi-Newton method %
% with an *analytic* gradient %

%options = optimset('GradObj','on','TolFun',1.e-9,'TolX',1.e-
10,'MaxIter',500,'MaxFunEvals',100000)
```

```
%[theta2,fval,exitflag,output] =
fminunc({@gmmobjg,@gradobj},theta2,options)

% the following line computes the estimates using a simplex search method
options = optimset('GradObj','on','TolFun',1.e-9,'TolX',1.e-
10,'MaxIter',100000,'MaxFunEvals',100000);
[theta2,fval,exitflag,output] = fminsearch('gmmobjg',theta2,options);

comp_t = toc/60;  % Stop stopwatch and record time

% computing the s.e.
vcov = var_cov(theta2);
se = sqrt(diag(vcov));

theta2w = full(sparse(theti,thetj,theta2));
t = size(se,1) - size(theta2,1);
se2w = full(sparse(theti,thetj,se(t+1:size(se,1))));

% the MD estimates
omega = inv(vcov(2:26,2:26));
xmd = [x2(1:25,1) x2(1:25,3:5)];
ymd = theta1(2:26);
beta = inv(xmd'*omega*xmd)*xmd'*omega*ymd;
resmd = ymd - xmd*beta;
semd = sqrt(diag(inv(xmd'*omega*xmd)));
mcoef = [beta(1); theta1(1); beta(2:4)];
semcoef = [semd(1); se(1); semd(2:4)];
Rsq_G = 1-(resmd'*omega*resmd)/((ymd-mean(ymd))'*omega*(ymd-mean(ymd)));
Chisq = size(id,1)*resmd'*omega*resmd;

diary results
disp(horz)
disp('  ')

     for i=1:size(theta2w,1)
          disp(vert(i,:))
          disp([mcoef(i) theta2w(i,:)])
          disp([semcoef(i) se2w(i,:)])
     end

     disp(output)
     disp(['GMM objective:  ' num2str(fval)])
     disp(['Chi-squared:  ' num2str(Chisq)])
     disp(['MD weighted R-squared:  ' num2str(Rsq_G)])
     disp(['run time (minutes):  ' num2str(comp_t)])
     diary off
```

```
function f=gmmobj(theta2)
% Originally written by Aviv Nevo
% This function computes the GMM objective function

global invA theta1 x1 IV

delta=meanval(theta2);

%.....................................................................
if max(isnan(delta))==1
    f=1e+10;
else
   temp1=x1'*IV;
   temp2=delta'*IV;
   theta1=inv(temp1*invA*temp1')*temp1*invA*temp2';
   clear temp1 temp2
   gmmresid=delta-x1*theta1;
   temp1=gmmresid'*IV;
   f=temp1*invA*temp1';
   clear temp1
   save gmmresid gmmresid
end

disp(['GMM objective:   '  num2str(f)])
```

```
function f = ind_sh(expmval,expmu)
% Originally written by Aviv Nevo
% This function computes the "individual" probabilities of choosing each
brand

global ns cdindex cdid
eg = expmu.*kron(ones(1,ns),expmval);
temp = cumsum(eg);
sum1 = temp(cdindex,:);
sum1(2:size(sum1,1),:) = diff(sum1);

denom1 = 1./(1+sum1);
denom = denom1(cdid,:);
f = eg.*denom;
```

```
function f=cr_dum(long_id)
% cr_dum    This function creates a set of dummies for each of the values
defined by long_id
b = sort(long_id);
b1 = [1;diff(b)];
b2 = b(b1>0);
clear b1 b
f = sparse(zeros(size(long_id,1), size(b2,1)));
for i = 1:size(b2,1)
    f(:,i) = sparse((long_id==b2(i)));
end
```

```
function f = jacob(mval,theta2)

% Originally written by Aviv Nevo
% This function computes the Jacobian of the implicit function that defines
the mean utility

global ns theti thetj cdid cdindex x2 vfull dfull theta2

theta2w = full(sparse(theti,thetj,theta2));

expmu = exp(mufunc(x2,theta2w));
shares = ind_sh(mval,expmu);
clear expmu

[n,K] = size(x2);
J = size(theta2w,2) - 1;
f1 = zeros(size(cdid,1),K*(J + 1));

% computing (partial share)/(partial sigma)
for i = 1:K
    xv = (x2(:,i)*ones(1,ns)).*vfull(:,ns*(i-1)+1:ns*i);
    temp = cumsum(xv.*shares);
    sum1 = temp(cdindex,:);
    sum1(2:size(sum1,1),:) = diff(sum1);
    f1(:,i) = mean((shares.*(xv-sum1(cdid,:)))')';
    clear xv temp sum1
end

% If no demogr comment out the next para
% computing (partial share)/(partial pi)
 for j = 1:J
d = dfull(:,ns*(j-1)+1:ns*j);
    temp1 = zeros(size(cdid,1),K);
    for i = 1:K
        xd=(x2(:,i)*ones(1,ns)).*d;
        temp = cumsum(xd.*shares);
        sum1 = temp(cdindex,:);
        sum1(2:size(sum1,1),:) = diff(sum1);
        temp1(:,i) = mean((shares.*(xd-sum1(cdid,:)))')';
        clear xd temp sum1
    end
    f1(:,K*j+1:K*(j+1)) = temp1;
```

```
    clear temp1
end

rel = theti + (thetj - 1) * max(theti) ;

% computing (partial delta)/(partial theta2)

f = zeros(size(cdid,1),size(rel,1));
n = 1;
for i = 1:size(cdindex,1)
    temp = shares(n:cdindex(i),:);
    H1 = temp*temp';
    H = (diag(sum(temp')) - H1)/ns;
    f(n:cdindex(i),:) = - inv(H)*f1(n:cdindex(i),rel);
    n = cdindex(i) + 1;
end
```

```
function f=meanval(theta2)

% Originally written by Aviv Nevo
% This function computes the mean utility

global theti thetj x2 s_jt theta2w
load mvalold

%.......................................................................
if max(abs(theta2-oldt2))<0.01
    tol=1e-9;
    flag=0;
else
    tol=1e-9;
    flag=1;
end

%.......................................................................
theta2w=full(sparse(theti,thetj,theta2));
expmu=exp(mufunc(x2,theta2w));
norm=1;
avgnorm=1;

%.......................................................................
i=0;
while norm>tol*10^(flag*floor(i/50))&&avgnorm>1e-3*tol*10^(flag*floor(i/50))

mval=mvalold.*s_jt./mktsh(mvalold,expmu);

  t=abs(mval-mvalold);
   norm=max(t);
   avgnorm=mean(t);
   mvalold=mval;
   i=i+1;
```

```
end

disp(['# of iterations for delta convergence:  ' num2str(i)])

%.....................................................................
if flag==1& max(isnan(mval))<1;
    mvalold=mval;
    oldt2=theta2;
    save mvalold mvalold oldt2
end
f=log(mval);
```

```
 function f=mktsh(mval,expmu)
% Originally written by Aviv Nevo
% This function computes the market share for each product

global ns
f=sum((ind_sh(mval,expmu))')/ns;
f=f';
```

```
function f=mufunc(x2,theta2w)
% Originally written by Aviv Nevo
% This function computes the nonlinear part of the utility

global ns vfull dfull
[n k]=size(x2);
j=size(theta2w,2)-1;
mu=zeros(n,ns);

for i=1:ns
    v_i=vfull(:,i:ns:k*ns);
    d_i = dfull(:,i:ns:j*ns);

    mu(:,i)=(x2.*v_i*theta2w(:,1))+x2.*(d_i*theta2w(:,2:j+1)')*ones(k,1);

end
f=mu;
```

```
function f=var_cov(theta2)
% Originally written by Aviv Nevo
% This function computes the vcov matrix of the estimates

global invA IV x1
load mvalold
load gmmresid

N=size(x1,1);
Z=size(IV,2);
temp=jacob(mvalold,theta2);

a=[x1 temp]'*IV;
IVres=IV.*(gmmresid*ones(1,Z));
b=IVres'*IVres;
f = inv(a*invA*a')*a*invA*b*invA*a'*inv(a*invA*a');
```

```
%This part is for supply side, calculate elasticities, markup, mc
%Run this code after running demand side estimation
%Coded by Yan Heng, based on Knittel and Metaxoglou (2012) and Vardges Hovhannisyan
%
%
%clear all

% load data

global invA ns x1 x2 s_jt IV vfull dfull theta1 theta2 theti thetj cdid cdindex
muf=mufunc(x2,theta2w);
meanv=meanval(theta2);
prob=ind_sh(exp(meanv),exp(muf));
prob_1=1-prob;
br=data(:,1);

vfull1=vfull(:,1:ns);
alpha_i=[];
price=x2(:,2);
            for i=1:size(vfull1,1)

alpha_i(i,:)=vfull1(i,:).*(kron(theta2(1),ones(1,ns)))+(kron(theta1(1),ones(1,ns)));
            end

            alphai=alpha_i;

            deriv_all=zeros(max(nbrn),max(nbrn),nmkt);
            elast_all=zeros(max(nbrn),max(nbrn),nmkt);

            for i=1:nmkt

                ind=cdid==i;
                pjt=price(ind,:);
                sjt=s_jt(ind,:);
                alpha_i=alphai(ind,:);

                 prob_jt=prob(ind,:);
                 prob_jt_1=prob_1(ind,:);

                elast=zeros(size(pjt,1),size(pjt,1));
                deriv=zeros(size(pjt,1),size(pjt,1));

                for j=1:size(pjt,1)
                     for k=1:size(pjt,1)

                         if k==j

deriv(j,j)=(1/ns)*sum(alpha_i(j,:)*(prob_jt(j,:).*prob_jt_1(j,:))');

elast(j,j)=(pjt(j)/sjt(j))*(1/ns)*sum(alpha_i(j,:)*(prob_jt(j,:).*prob_jt_1(j,:))');

                        elseif k~=j
                           deriv(j,k)=-
(1/ns)*sum(alpha_i(j,:)*(prob_jt(j,:).*prob_jt(k,:))');
```

```
                            elast(j,k)=-
(pjt(k)/sjt(j))*(1/ns)*sum(alpha_i(j,:)*(prob_jt(j,:).*prob_jt(k,:))');


                        end

                    end

                end

                elast_all(1:size(elast,1),1:size(elast,2),i)=elast;
                deriv_all(1:size(deriv,1),1:size(deriv,2),i)=deriv;

            end

            %store own and cross price elasticities
            temp=[];
            temp2=[];
            for j=1:nmkt;
                temp=[temp; (elast_all(:,:,j))];
                temp2=[temp2; diag(elast_all(:,:,j))];
            end
            elast_all=temp;
            elast_own=temp2;



%own-price elas median
e2=[];
   for i=1:max(br)
                e3=median(elast_own(br==i,:));
                e2=[e2;e3];
   end
%cross-price elas median
   e4=[];
   for i=1:max(br)
       e5=median(elast_all(br==i,:));
       e4=[e4;e5];
   end


%calculate markup, mc, lerner index
brand=data(1:25,1);
company=data(1:25,3);
own=cr_dum(company); %under current ownership of multi-products
%own=cr_dum(brand); %each product belongs to different company
%own=data(1:25,2); %monopoly


            sjt=(1/ns)*sum(prob')';

            mm=[];
            for i=1:max(cdid)
                p=price(cdid==i,:);
```

```
        s=sjt(cdid==i,:);
        om=deriv_all(:,:,i).*(own*own');
        m=-inv(om')*s;
        mm=[mm;m];
    end

    margin=mm;
    mc=price-margin;
    lerner_pct=(margin)./price;
```

```
%simulated p for elasticities, run after estimating the supply side%
%for multi-product firms structure

global invA ns x1 x2 s_jt IV vfull dfull theta1 theta2 theti thetj cdid
cdindex


vfull1=vfull(:,1:ns);
alpha_i=[];
price=x2(:,2);

mtheta2=theta2; %mean parameters
vartheta2=vcov(27:41,27:41); %vcov
numbsims=1000; %simulate 1000 times
ran=mvnrnd(mtheta2,vartheta2,numbsims); %simulate 1000 coefficients

for t=1:numbsims
meanv=meanval(ran(t,:)')
theta2wv = full(sparse(theti,thetj,ran(t,:)'));
muf=mufunc(x2,theta2wv);
prob=ind_sh(exp(meanv),exp(muf));
prob_1=1-prob;

temp1=x1'*IV;
temp2=meanv'*IV;
theta1v=inv(temp1*invA*temp1')*temp1*invA*temp2';
clear temp2;



            for i=1:size(vfull1,1)

alpha_i(i,:)=vfull1(i,:).*(kron(ran(t,1),ones(1,ns)))+(kron(theta1v(1),ones(
1,ns)));
            end

            alphai=alpha_i;

            deriv_all=zeros(max(nbrn),max(nbrn),nmkt);
            elast_all=zeros(max(nbrn),max(nbrn),nmkt);

            for i=1:nmkt % for each market
                ind=cdid==i; %calculate els for each product
                pjt=price(ind,:);
                sjt=s_jt(ind,:);
                alpha_i=alphai(ind,:);

                 prob_jt=prob(ind,:);
                 prob_jt_1=prob_1(ind,:);

                elast=zeros(size(pjt,1),size(pjt,1));
                deriv=zeros(size(pjt,1),size(pjt,1));

                for j=1:size(pjt,1)
```

```
                    for k=1:size(pjt,1)

                        if k==j %own-price elas

deriv(j,j)=(1/ns)*sum(alpha_i(j,:)*(prob_jt(j,:).*prob_jt_1(j,:))');

elast(j,j)=(pjt(j)/sjt(j))*(1/ns)*sum((alpha_i(j,:)*(prob_jt(j,:).*prob_jt_1
(j,:))'));

                       elseif k~=j %cross-price elas
                          deriv(j,k)=-
(1/ns)*sum(alpha_i(j,:)*(prob_jt(j,:).*prob_jt(k,:))');
                          elast(j,k)=-
(pjt(k)/sjt(j))*(1/ns)*sum((alpha_i(j,:)*(prob_jt(j,:).*prob_jt(k,:))'));


                       end

                   end

               end

               elast_all(1:size(elast,1),1:size(elast,2),i)=elast;
               deriv_all(1:size(deriv,1),1:size(deriv,2),i)=deriv;
           end

           %store own and all price elasticities
           temp=[];
           temp2=[];
           for j=1:nmkt;
               temp=[temp; (elast_all(:,:,j))];
               temp2=[temp2; diag(elast_all(:,:,j))];
           end
           elast_all=temp;
           elast_own=temp2;

%median elas by product
   e4=[];
   for i=1:max(br)
       e5=median(elast_all(br==i,:));
       e4=[e4;e5];
   end

   elast_m(1:size(e4,1), 1:size(e4,2), t)=e4;


end

%now sort each median elasticity
for s=1:max(br)
    for m=1:max(br)
    sortedesim(s,m,:)=sort(elast_m(s,m,:));
end
end
```

```
 %test if each elas is different from 0, p-val
 for t=1:numbsims
     for s=1:max(br)
         for m=1:max(br)
     if sortedesim(s,m,:)>0 numbsortedsim(s,m,:)=1;else
numbsortedsim(s,m,:)=0;end
     pnum(s,m)=sum(numbsortedsim(s,m,:))/numbsims;
     end
     end

 end
```

Appendix B– Stata Codes for Non-Nested Tests for Model Selection

```
///Please see Gayle and Brown (2015), pp35-37, for details//////

clear all
import excel "C:\Users\Yan\Google Drive\ksu\egg consumption\scanner
data\structure test.xls", sheet("Sheet3 (2)") firstrow

gen y1=p-mul //mul is the estimated markup under multi-product firms
structure, p is price
reg y1 pro1-pro25 corn soy ele //regress y1 on fixed brand effects, marginal
cost variables (instrument variables)
predict e1,residual //save residual
gen y2=p-single //single is the estimated markup under joint ownership
structure
reg y2 pro1-pro25 corn soy ele
predict e2,residual
gen y3=p-ind //ind is the estimated markup under single product firm
strucutre
reg y3 pro1-pro25 corn soy ele
predict e3,residual
egen m1=sd(e1) //calculate standard deviation of residual
gen l1=lnnormalden(e1/m1) //estimate log of standard normal probability
density function
egen m2=sd(e2)
gen l2=lnnormalden(e2/m2)
egen m3=sd(e3)
gen l3=lnnormalden(e3/m3)
gen diff1=l1-l2
gen diff2=l1-l3
egen lr1=total(diff1) //calculate LR on page 36 for multi-product firms and
joint ownership
egen td1=total(diff1^2)
gen v21=td1/575-(lr1/575)^2 //calculate V squared on page 36
gen q1=575^(-.5)*lr1/sqrt(v21) //calculate q on page 36
```

```
egen lr2=total(diff2) //calculate LR on page 36 for multi-product firms and
single product firms
egen td2=total(diff2^2)
gen v22=td2/575-(lr2/575)^2//calculate V squared on page 36
gen q2=575^(-.5)*lr2/sqrt(v22) //calculate q on page 36
```