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Getting Something from Nothing: An Investigation of Beef Demand Expansion and Substitution in the Presence of Quality Heterogeneity

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Abstract

A relative increase in demand for quality can have one of two potentially countervailing effects: it can cause substitution of one quality for another and/or it might expand overall demand by bringing new consumers into the market. This article investigates demand expansion and substitution among beef qualities by exploiting the use of a no-purchase option in a non-hypothetical choice experiment involving real food and real money. A random parameters logit model, which permits very flexible substitution patterns, is used to show that expanding demand for high quality rib-eye steak increases revenue by a greater degree than expanding demand for low quality steak. Regardless of whether high or low quality demand is expanded, the expansion effect dominates the substitution effect. We also show that the introduction of a new “natural” steak causes a greater reduction in market share for high quality than low quality beef, but despite this overall steak demand increases. These results have important implications for the manner in which collective advertising is conducted and for the effects of new product introductions on industry profitability.

Commodity organizations face a daunting task in identifying the effects of promotion and new product introduction. Commodity markets are large and complex, consisting of many differentiated products sold at different prices in different markets. Disaggregated data on sales of quality-differentiated products are both rare and expensive. Ideally, one would exogenously control the prices of each product at a particular location and vary each price randomly, allowing for a precise calculation of demand elasticities. This procedure would then be repeated at many locations. Only after this would one have an accurate depiction of market demand such that promotion and new product introduction effects could be determined.

Unfortunately, such data are not available, and the data that are available often suffer from aggregation and endogeneity problems. An alternative is to utilize recent advances in choice experiment methods to simulate markets with only a consumer panel. Choice experiments (CE) and conjoint analysis are increasingly being used by economists to understand how consumers view the trade-offs between existing goods and the market impacts of new product introduction. These methods allow economists to determine willingness-to-pay for product attributes and estimate market share for new quality differentiated products. In a CE, participants choose one of several competing options described by differing product attributes and prices. One reason for the methods' popularity is that it mimics consumers' actual purchasing decisions: making a choice between competing goods. To mimic the typical shopping experience, practitioners are typically urged to include a "no purchase" or "none" option (e.g., Holmes and Adomowicz; Dhar; Dhar and Nowliss; Dhar and Simonson; Louviere, Hensher, and Swait). This allows the respondent to opt out of the purchase altogether, which of course is an option available consumers when confronted with an actual purchase decision.

Without a “no purchase” option the resulting probabilities are conditional probabilities; conditional on the consumer making a purchase.

Another motivation for including a no-purchase option is that it sets the base utility level to which all other alternatives are compared (Louviere). Furthermore, Dhar suggests that the no-choice option allows the researcher to identify cases of ‘preference uncertainty,’ which occurs when consumers are unable to choose among alternatives because no clear best alternative exists. Dhar and Simonson add that the no-choice option draws its share unequally from the other alternatives. Specifically they suggest that the no-choice option draws disproportionately from alternatives that are average across the characteristics that are of interest. But, for whatever reason a no-purchase option might be included in a study, it is often treated as a nuisance that must be controlled for econometrically, but with no meaningful economic interpretation.

The contribution of this research is the insight that important economic information can be gleaned from a fuller investigation of how consumers substitute between the “none” option and other available alternatives. The preceding discussion might appear to have relevance only to CE practitioners; however, the underlying issues have important implications for a variety of economic analyses (e.g., Dhar and Nowlis). For example, a firm might be interested in determining whether introducing a new product will attract new consumers or cannibalize sales of existing products. As another example, consider the effect of generic advertising for agricultural commodities. Alston, Freebairn, and James showed that because aggregate meat products such as beef and pork are demand substitutes, there is an optimal mix of promotion that is obtainable by advertising such that the substitution effects are minimized while overall meat demand is maximized. However, meat products are heterogeneous with respect to quality and consumers have the ability to substitute not just between meat types, but between different

qualities within type. This observation implies that there are optimal demand expansion strategies *within* meat types.

Although it is clear that such issues are economically important, analysis is limited by existing data and research methods. For example, government agencies tend to only track price and quantity data for aggregate products; information on quality within product is severely limited. Even when disaggregated data, such as scanner data, is available it is difficult to identify individuals that choose not to purchase at any particular point in time, making it difficult to characterize overall demand expansion effects (e.g., see Nevo). Scanner data, and even aggregate data in some cases, can be helpful in estimating *ex post* effects of new product introduction (e.g., Dhar and Foltz), but is of little use if one is interested in *ex ante* effects, the latter of which are of more relevance to agribusinesses and policy makers.

In this paper, we utilize an approach that is able to overcome each of these problems. The objective of this research is to conduct a consumer experiment to generate data to estimate a demand model that permits flexible substitution patterns between beef qualities and a “no purchase” option. The model will be used to determine whether expanding high or low quality beef-steak demand has a larger effect on overall beef-steak demand. This result will likely be driven by the degree to which expanding demand of one quality tends to cannibalize demand of the other quality rather than drawing from the “none” option. Finally, we consider how the introduction of a new “natural” steak will affect market structure. Specifically, we are most interested in whether introducing the new product expands overall demand for steak or whether it tends to predominately draw share from pre-existing cuts. The next section of the paper provides more background on our particular application. Then, we discuss conceptual and econometric issues. The forth section describes our experiment. The latter two sections contain the results

and conclusions. Overall, our findings suggest that beef industry participants might consider promotion efforts that target particular beef qualities.¹

Beef Demand and Commodity Beef Advertising

A substantial amount of research on generic advertising of agricultural commodities has been conducted (e.g., Alston, Chalfant, and Piggott; Alston, Freebairn, and James; Brester and Schroeder; Hyde and Foster; Wohlgenant). In a typical study, demand models are estimated using aggregate time-series data, where interest lies in identifying own- and cross-commodity advertising effects. Recently, research has begun to focus on characterizing the distribution of benefits from generic promotion to different firms that are all equally charged for the programs (e.g., Chung and Kaiser).

Some research has quantified the benefits to producers and consumers from generic advertising. For instance, Piggott, Piggott and Wright measured the farm-level return to advertising. Their model suggests that some groups of meat producers over-advertise to compete with generic advertising of other substitute products. However, their results are inconclusive as to whether advertising is profitable to producers. Alston, Chalfant, and Piggott contend that the estimated impacts of generic advertising in prior studies were incomplete because such models did not consider social welfare. They calculate the change in total producer surplus for beef, pork, and poultry producers, consumer surplus, and tax revenues. Their estimates indicate total welfare is often reduced when advertising expenditures for competing meat products are increased.

¹ Before proceeding, one point should be made clear. The methods employed in this paper do not deal with the effects of advertising *per se*. We investigate the effect of expanding demand for one quality, but are agnostic how such demand expansion occurs and how costly it might be to achieve such expansion. Further, we do not address whether it is more or less costly to expand demand for high or low quality.

Alston, Freebarin, and James considered the potential effects of cooperative advertising among meat industry participants. They derived an optimal level of generic advertising that maximizes the sum of profits across the different groups of meat producers. Their empirical example suggested that overinvestment in advertising occurred with generic promotion programs and some producers were hurt at the expense of producers of strategic substitutes.

This research suggests that expanding demand for all meat products at an aggregate level tends to benefit one producer group at the expense of others and that it is difficult to measure the impacts at the farm level. These results might cause concern for groups trying to differentiate their product from a more generic commodity, e.g. Certified Angus Beef or “natural” steaks produced without growth hormones or antibiotics. Generic advertising for commodity products might diminish efforts at differentiating a product. Indeed, Brester and Schroeder found that both generic and branded advertising affected beef, pork, and chicken demand. Crespi and Marette found that product heterogeneity is an important consideration when assessing the impacts of generic advertising. They demonstrated that generic promotion could negatively impact producers of a quality differentiated good. Generic advertising might cause consumers to view all products similarly, causing substitution from a potentially higher quality, differentiated product to a generic product. Although the case was not true in their empirical application, Crespi and Marette’s results suggest that it is possible for generic advertising, rather than increasing overall demand, might simply cause substitution between existing goods.

These results imply that it should be of interest for a commodity organization to determine whether is possible to more efficiently allocate generic advertising dollars. Take for example the beef industry. High quality steaks such as USDA Choice and Prime are of high intramuscular fat content and tend to be sold predominately in restaurants, whereas lower quality

steaks such as USDA Select are of low intramuscular fat content and tend to sell predominately in grocery stores. Advertising “health” benefits of beef would serve to promote Select beef, whereas advertising “taste” benefits of beef would serve to promote Choice or Prime. In the same vein, beef advertising could focus on increasing at-home consumption or away-from-home consumption, which would tend to favor one quality over another. The interesting question is whether such targeting advertising would increase overall beef demand or whether consumers would predominantly substitute between qualities.

In addition to the issue of the effect of advertising and demand expansion on quality, many agricultural sectors have experienced increased product differentiation. That is, new products, which are extensions of pre-existing products, are being introduced into the market. For example, Dhar and Foltz investigate the *ex post* effects of the introduction of organic and rBST free milk. Their estimated price elasticities show that conventional, unlabeled milk is a demand substitute for rBST free and organic milk suggesting that the introduction of these new products likely caused a reduction in quantity of conventional milk demanded. While their results indicate that introduction of the new differentiated milk products was welfare enhancing for consumers, it is not clear that it was welfare enhancing for milk producers, in aggregate. In this paper, we focus on beef steaks. A number of studies have investigated consumer demand for beef steak attributes, including “natural” beef produced without growth hormones or antibiotics (e.g., Lusk, Roosen, and Fox; Lusk, Feldkamp, and Schroeder). However such studies have almost exclusively focused on estimating willingness-to-pay for a new product over a conventional counterpart. It is less clear, in a multi-good context, whether introduction of a natural beef steak will cause substitution amongst existing cuts, which cuts have the greatest

substitutability with the natural product, and whether introduction of the natural product will bring new consumers into the market.

Conceptual Considerations

This analysis works within the random utility framework introduced by McFadden. Assume consumer i , derives the following utility for product j : $U_{ij} = V_{ij} + \varepsilon_{ij}$, where V_{ij} is the deterministic and ε_{ij} is the stochastic portion of utility. For simplicity and consistency with subsequent analysis, let the systematic portion of the utility function for option j be:

$$(1) \quad V_{ij} = \alpha_j + \beta_j PR_j,$$

where α_j is an alternative specific constant that embodies the utility an individual derives from all the non-price attributes of alternative j , β_j is the marginal utility of price which is permitted to vary across j choice options, and PR_j is the price of alternative j .

If faced with J choice options an individual chooses option j if $U_{ij} > U_{ik}$ for all $j \neq k$. If the ε_{ij} are distributed iid extreme value, then the probability of individual i choosing option j is:

$$(2) \quad P_{ij} = \frac{e^{V_{ij}}}{\sum_{k=1}^J e^{V_{ik}}}$$

as shown by Train.

Let the last option, option J , be the “no purchase” option. Without loss of generality, the systematic portion of utility for this option is set at zero. Thus, the alternative specific constants, α_j , for options $j \neq J$ indicate the utility of option j relative to not purchasing. Given this definition, willingness-to-pay (WTP) for alternative j versus buying no product at all is $-\alpha_j/\beta_j$. If one takes an industry-level perspective, it is helpful to consider the choice probability for any

purchased good. This purchase probability is defined as: $\Sigma P_{j \neq J} = \sum_{k \neq J} P_{ik} = 1 - P_J$.

$\Sigma P_{j \neq J}$ represents the likelihood that an individual will purchase any good, regardless of the type.

The first issue of interest in this study is how a change in demand for product j affects 1) purchase probabilities for option j (i.e., the own-good effect), 2) purchase probabilities for options $k \neq j$ (i.e., the substitution effect), and 3) $\Sigma P_{j \neq J}$ (i.e., the expansion effect). To investigate these issues, consider a particular form of demand expansion where the relative preferences for *one* of the purchase options increases. In the discrete case, one can think of the utility of *one* option changing from $V_{ij} = \alpha_j + \beta_j PR_j$ to $V_{ij}^* = \gamma_j + \beta_j PR_j$, where $\gamma_j > \alpha_j$. For sake of convenience, consider the effect of a marginal increase in α_j .² If the population is described by the multinomial logit (MNL) as in equation (2) above, the own-good effects of this change are:

$\frac{\partial P_{ij}}{\partial \alpha_j} = P_{ij}(1 - P_{ij})$. The substitution effects of the demand increase in option j on good k are:

$\frac{\partial P_{ik}}{\partial \alpha_j} = -P_{ij}P_{ik}$. Finally, the expansion effect is given by:

$\frac{\partial \Sigma P_{j \neq J}}{\partial \alpha_j} = P_{ij}(1 - P_{ij}) - \sum_{j \neq J} P_{ij}P_{ik} = P_{ij}P_{iJ}$. Alternatively, one can express the effect of a demand

shift in percentage terms. The effect of a one-percent increase in α_j on P_{ij} , P_{ik} and $\Sigma P_{j \neq J}$ are respectively, $\alpha_j(1 - P_{ij})$, $-\alpha_j P_{ij}$, and $\alpha_j P_{ij}P_{iJ}(1 - P_{iJ})$. Thus, increasing relative demand for good j , increases the probability of purchasing j , decreases the purchase probability of all other goods $k \neq j$, and increases the share of individuals actually making a purchase.

We are also interested in the effect of introducing a new good, say good $J + 1$, on purchase probabilities. First, note that prior to the introduction of the new good, the log

² In our empirical analysis, we consider the effect of increasing the alternative specific constant in such a manner that WTP for option j increases either by one-dollar or one-percent.

probability of purchasing good j is given by $\ln(P_{ij}^0) = V_{ij} - \ln(\sum_{k=1}^J e^{V_{ik}})$, where the last term,

$\ln(\sum_{k=1}^J e^{V_{ik}})$ is approximately equal to the expected maximum utility from making a choice (Small

and Rosen). When a new good is introduced, the log probability of purchasing j is

$\ln(P_{ij}^1) = V_{ij} - \ln(\sum_{k=1}^{J+1} e^{V_{ik}})$. Thus, the effect of the new good introduction is

$$(3) \quad \ln(P_{ij}^1) - \ln(P_{ij}^0) = \ln(\sum_{k=1}^J e^{V_{ik}}) - \ln(\sum_{k=1}^{J+1} e^{V_{ik}}) = E[\max U^0] - E[\max U^1].$$

So long as there is some probability of the new good having value and therefore being chosen, the maximum expected utility rises relative to the case where the good was not available and P_{ij} falls.³

Unfortunately, there are some severe limitations to using (2) to describe consumer behavior. For example, the effect of a one-percent increase in α_j on P_{ik} is $-\alpha_j P_{ij}$, an effect that is the same for all k , a highly unrealistic assumption. In addition, an increase in α_j necessarily increases the likelihood of making a purchase with the MNL, which degrades the ability to investigate of the key issues in this study. These findings are a consequence of the iid assumption of the error term and this assumption results in the independence of irrelevant alternatives property (IIA). This property is particularly undesirable when considering the effects of introduction of a new product. For example, equation (3) shows that the change in log probability after the introduction of a good is equivalent for all goods j . So, the introduction of a new good will cause all goods to reduce their market share proportionately. It is also straightforward to see from equation (2) that $P_{ij} / P_{ik} = e^{V_{ij} - V_{ik}}$ implying that the ratio of the

³ Once can equivalently conceptualize the effect of introducing a new good, $J+1$, as reducing its price from infinity to PR_{J+1} .

probability of purchase for any two alternatives does not depend on what other alternatives are available or the level of the attributes of other alternatives. Thus, if a new good is introduced, the ratio of probabilities of all other existing goods remains constant forcing the new good to draw proportionally from all goods.

A more flexible representation of behavior in a population of individuals can be achieved by allowing for heterogeneity in preferences. In particular, assume that the alternative specific constants above (let α denote a vector of all α_j terms) are distributed in the population according to the distribution $f(\alpha)$. Now, preferences can be described via a mixed logit (Train). The probability of alternative j becomes:

$$(3) \quad P_{ij} = \int \frac{e^{V_{ij}}}{\sum_{k=1}^J e^{V_{ik}}} f(\alpha) d\alpha,$$

which is the average logit formula above weighted by $f(\alpha)$. The probability of purchase conditional on α is simply the MNL in equation (2).

The mixed logit permits flexible substitution patterns between goods and is not subject to the IIA property. For instance, the ratio of any two probabilities now depends on the presence of other alternatives and their attribute levels as the summation terms in (3) do not cancel in the division as they did for the MNL. Substitution patterns between alternatives are also less restrictive. For example, a one-percent increase in demand for alternative j , has the following effect:

$$(4) \quad \frac{\partial P_{ik}}{\partial \alpha_j} \frac{\alpha_j}{P_{ik}} = - \int P_{ik}(\alpha) \frac{P_{ij}(\alpha)}{\int \frac{e^{V_{ij}}}{\sum_{k=1}^J e^{V_{ik}}} f(\alpha) d\alpha} f(\alpha) d\alpha.$$

McFadden and Train (2000) show that the mixed or random parameters logit (RPL) can approximate any random utility model, making it an especially appealing choice for this application. The important trait of the RPL in conjunction with a consumer panel is that, a priori, any outcome is possible; increasing the demand for one good may or may not cannibalize sales of another good. The outcome is driven completely by consumer preferences.

Value of Nothing

To make clear the value of including a “none” option in a choice experiment, suppose that a good can be disaggregated into two types: H and L. Suppose a choice experiment were conducted that permitted one to calculate the probability of choosing H or L at prices PR_H and PR_L , respectively. If these two goods are the only choices, the probabilities will sum to one. Let the market shares for H and L at any particular combination of prices be $M_H(PR_H, PR_L)$ and $M_L(PR_H, PR_L)$, respectively. Then, let N be the size of the population multiplied by the average number of choices per person per year. The quantity demanded of each good is:

$$\begin{aligned}
 QD_H &= N * M_H(PR_H, PR_L) \\
 (5) \quad QD_L &= N * M_L(PR_H, PR_L) \\
 M_H(PR_H, PR_L) + M_L(PR_H, PR_L) &= 1
 \end{aligned}$$

where QD is total quantity demanded for type H or L. Once the supply conditions are stated, the market is complete. Assume constant returns to scale in the long-run, which generates perfectly elastic supply curves. This requires that the inverse supply curves equal long-run minimum average costs, such as

$$\begin{aligned}
 (6) \quad PR_H &= \overline{PR}_H \\
 PR_L &= \overline{PR}_L
 \end{aligned}$$

The market equilibrium can be stated as

$$\begin{aligned}
(7) \quad & QD_H = N * M_H(\overline{PR}_H, \overline{PR}_L) \\
& QD_L = N * M_L(\overline{PR}_H, \overline{PR}_L) \\
& M_H(\overline{PR}_H, \overline{PR}_L) + M_L(\overline{PR}_H, \overline{PR}_L) = 1
\end{aligned}$$

The problem with this model is that changes in total consumption are not identifiable. That is, one can estimate how shifts in demand for good H will affect the probability of an individual choosing L, but not how demand is altered. The model requires that $dM_H = -dM_L$, which says that if the probability of choosing H increases by say 1%, the probability of choosing L must fall by 1%. By only allowing two choices, the model imposes the nonsensical constraint that total demand cannot change. For example, the model requires that

$$(8) \quad d(QD_H + QD_L) = N[dM_H(\overline{PR}_H, \overline{PR}_L) + dM_L(\overline{PR}_H, \overline{PR}_L)] = 0.$$

This is where a no-choice option becomes useful. As before, let the no-choice option yield zero utility and a constant price of zero. This consequently redefines the no-choice option as an imaginary good. The market share for this imaginary good can be calculated just like real goods; define this market share as $M_I(PR_H, PR_L, 0)$ where the last term in brackets is the cost of the imaginary good. Since the good is imaginary, we can assume its demand is given simply as $M_I(PR_H, PR_L, 0)$ times zero. This ensures that the quantity consumed always remains zero, since it is a no-choice option, but allows a greater or smaller percent of the population to consume zero. The equilibrium conditions are now

$$\begin{aligned}
(9) \quad & QD_H = N * M_H(\overline{PR}_H, \overline{PR}_L, 0) \\
& QD_L = N * M_L(\overline{PR}_H, \overline{PR}_L, 0) \\
& QD_I = 0 * M_I(\overline{PR}_H, \overline{PR}_L, 0) \\
& M_H(\overline{PR}_H, \overline{PR}_L, 0) + M_L(\overline{PR}_H, \overline{PR}_L, 0) + M_I(\overline{PR}_H, \overline{PR}_L, 0) = 1
\end{aligned}$$

The market share constraint now undergoes a different interpretation. Before, it was the allocation of choices across H and L conditional on a purchase. Now, it should be interpreted as

the allocation of *all* choices across H, L, and the imaginary good. Now, the change in total commodity consumed is

$$(10) \quad d(QD_H + QD_L) = N[dM_H(\bar{P}\bar{R}_H, \bar{P}\bar{R}_L) + dM_L(\bar{P}\bar{R}_H, \bar{P}\bar{R}_L)],$$

and since $dM_H(\bar{P}\bar{R}_H, \bar{P}\bar{R}_L) + dM_L(\bar{P}\bar{R}_H, \bar{P}\bar{R}_L)$ does not have to equal one, total commodity demand can rise, fall, or stay the same.

Methods and Procedures

Experiment

This paper uses data collected in the non-hypothetical experiments used by Lusk and Schroeder.⁴ Sixty-seven subjects were randomly recruited from a midwestern college town by offering \$40 cash to participate in a CE. Subjects were given the opportunity to inspect five beef ribeye steaks (generic, guaranteed tender, “natural,” USDA Choice, and Certified Angus Beef) and were provided with an information sheet describing each of the steak types. The “generic” steak was described as a steak with no label that is similar to steaks found in a grocery store.

After reading the information sheet and completing a short questionnaire, subjects were asked to complete 17 different choice scenarios. For each scenario subjects were asked to choose among each of the five steaks or no purchase. Prices of each steak were varied across 16 scenarios according to an orthogonal fractional factorial design and a last scenario was added where all steaks were identically priced. An example decision task is given in figure 1. After all 17 choices were made, one of the choices was randomly selected as binding and individuals made the purchase the indicated in the binding scenario. To preserve the orthogonality of the design, responses to the 17th question were not used in subsequent econometric analysis. For this

⁴ We have carried out the analysis using the hypothetical data as well and, qualitatively, our results are very similar.

analysis, we removed six individuals from the data set who always chose the no purchase option.⁵ This procedure generates a total of 976 choices made by 61 individuals for use in analysis.

Econometric Model

Based on the framework outlined above, we estimated an RPL model using the choice data. In particular, we assume that the alternative specific constants, α , are jointly distributed normal with mean $\bar{\alpha}$ and variance-covariance matrix Ω . The i^{th} consumer's utility in matrix notation is $V_i = \bar{\alpha} + \bar{\beta}PR + \Gamma e_i$, where Γ is the Cholesky factor of Ω (e.g., $\Gamma'\Gamma = \Omega$) and e_i is a vector of random standard normal deviates. So, the alternative-specific constants for each of the five steaks (relative to no purchase) are permitted to vary randomly in the population and each steak constant is potentially correlated with other constants. To account for the panel-nature of the data (e.g., each individual made 16 choices), the e_i are assumed individual-specific. Following Layton and Brown, we fix the price effects, $\bar{\beta}$, in the population such that WTP is normally distributed and identifiable. The model above is estimated via simulation. In particular, the parameters are estimated by maximizing a simulated log-likelihood function, which is comprised of the average choice probability calculated at (in this case 500) pseudo-random Halton draws for e_i . See Train for computational details.

Demand Expansion and Production Introduction Simulations

To accomplish our stated objectives several simulations are carried using the estimated RPL parameters. Although the experiment involved individuals choosing between six alternatives, our simulations start with a base-line model where it is assumed individuals choose between one

⁵ We chose to delete these individuals because the goal of this analysis is to investigate how consumers substitute across beef qualities and these individuals did not make and trade-offs. Our results are very similar if these individuals are included in the analysis.

of three alternatives: purchase the generic steak, purchase the USDA Choice steak, or no purchase. The mean prices used in the experimental design are used as the steak prices in the simulations: the price for generic was set at \$5.065/12 oz steak and the price for USDA Choice was set at \$7.315/12 oz steak. As a first step, we simply calculate the estimated market share for each of the three alternatives at the stated prices.

To investigate demand expansion effects, we increase the alternative specific constant for one of the beef qualities and investigate how probabilities change from the base-line scenario.

The alternative specific constants are not increased in an arbitrary manner; we increase the alternative specific constant for one of the qualities such that mean WTP for that quality increases by either \$1 or 1%. Both cases are considered to investigate whether results are robust across absolute and percentage changes in demand. In the case of the \$1.00 increase in WTP, the original alternative specific constant for option j , α_j , is replaced with the new constant: $(\alpha_j + \beta_j)$.

It can be readily verified that this increases WTP for option j by \$1. In the case of a 1% mean WTP increase, the original alternative specific constant for option j is replaced with the new constant: $(1.01\alpha_j)$. First, we shift demand for the generic steak by \$1 or 1% and investigate changes in market shares. Then, we shift demand for the USDA Choice by \$1 or 1% and investigate changes in market shares. In addition to changes in market shares, we are also

interested in changes in revenue. In general, industry revenue is calculated as $N \sum_{k=1}^{J-1} P_{ik} PR_k$,

where N is the size of the population of interest multiplied by the number of choices made in a specific time period. In our two good case, steak industry revenue is simply $N(P_{\text{generic}} * PR_{\text{generic}} + P_{\text{Choice}} * PR_{\text{Choice}})$. As a last case, we consider the effect of introduction the “natural” steak into the market at a price equal to \$7.315. Estimated market shares and revenue after the natural steak is introduced are compared to the baseline.

Results

Parameter estimates for the RPL model are reported in table 1. All alternative specific constants are positive, indicating that *ceteris paribus*, having a steak is preferred to having no steak (e.g., the “none” option). The fact that the USDA Choice constant is higher than the generic constant implies consumers, on average, prefer Choice to generic, everything else held constant. All price effects are negative implying higher priced steaks are less likely to be chosen than lower priced steaks. Mean WTP (in \$ per 12 oz steak) for the generic and Choice steaks versus “none” are \$3.86 and \$7.07, respectively. Results indicate a significant degree of heterogeneity in preferences for all steaks except generic. For example, the standard deviation of the natural steak constant is 2.450 implying 95% of the population has a WTP for natural steak between \$2.43 and \$7.92, which is a substantial amount of variation. The covariance matrix of the random parameters, Ω , is given in table 2. Preferences for most steaks are positively correlated, which seems reasonable. It implies for example, that an individual that prefers a generic steak more than average is also likely to prefer a Choice steak more than average. The major exception is the natural steak, which is negatively correlated with all other steaks except Choice. Having high preferences for natural steak tends to be associated with low preferences for other steaks, which also seems reasonable.

It is these correlations that allow one to simulate market outcomes using only consumer panels (again, assuming perfectly elastic supply curves). Consider the case where the demand for Choice steaks is increased. Within the choice experiment sample, some individuals had a greater preference for Choice compared to generic steaks, as reflected by the standard deviation on the Choice steak intercept (see table 1). Let us refer to these as high-quality consumers. Increasing the demand for Choice steaks in a market is akin to increasing the percent of

consumers that are high-quality consumers. Suppose that high-quality consumers dislike generic steaks more compared to other consumers. This means that increasing the percent of high-quality consumers would decrease average preferences for generic steaks. If this were true, the model would reveal this information by a negative correlation in the intercepts for Choice and generic steaks. However, the estimated correlation is positive (table 2). This means that increasing the percentage of high-quality consumers implies that the average consumer now obtains more utility for both Choice and generic steaks, and the demand for both steak types rises. Another example is the impact of a Natural steak. Are consumers who tend to prefer Natural steaks also more inclined to purchase Choice steaks and less inclined to purchase generic steaks? Table 2 suggests that this is indeed true. This implies that introducing a Natural steak should decrease Choice steak purchases more than generic steaks.

Using the RPL estimate utility from a choice experiment provides information on how consumer preferences differ across individuals. It allows us to group consumers by their tastes, but more importantly, it allows us to simulate how the demand for quality differentiated goods changes as the percent of each consumer group changes, and therefore allows one to simulate market changes from a single panel of consumers. The important trait inherent in this approach is that, a priori, any outcome is possible. Increasing the demand for Choice steaks may or may not cannibalize sales of generic steaks. The outcome is driven completely by consumer preferences. To the extent that the consumer sample in the experiment adequately represents the population, a wide array of market impact scenarios can be analyzed.

Table 3 reports the market shares for each of the simulations. Under the base-line case, approximately 11% of consumers would be expected to purchase generic, 35% would be expected to purchase Choice, and 54% would be expected to choose none. Conditional on

making a purchase, the model predicts 23.5% of consumers would buy generic and 76.5% would buy Choice. These figures correspond reasonably well with USDA data which indicate that almost 60% of beef that was graded received the USDA Choice grade or higher. In the base-line case, expected revenue per choice occasion (i.e., per N) is \$3.13. Table 3 also reports the estimated market share from simulations when 2) generic WTP is increased 1%, 3) Choice WTP is increased 1%, 4) generic WTP is increased \$1, 5) Choice WTP is increased \$1, and 6) a “natural” steak is introduced. Tables 4 and 5 report absolute and percentage changes in estimated market shares, respectively, from the base-line scenarios.

Regardless of whether WTP expands in absolute or percentage terms, increasing Choice WTP has a larger effect on total beef purchases and on total steak revenue. For example, increasing WTP for Choice by \$1 increases Choice market share by 30.44% (an 86% increase over base-line market share), causing a 24.43% increase in the percentage of consumers expected to actually choose a steak cut and an increase of \$1.93 in expected revenue (a 62% increase). By contrast, increasing generic WTP by \$1 only increases total steak purchases by 10.52% and expected revenue by \$0.37. Results also indicate that the expansion effects dominate the substitution effects regardless of whether WTP for Choice or generic is increased. For example, increasing WTP for generic by 1%, while causing a 0.19% reduction in the fraction of individuals purchasing Choice, caused a 0.27% reduction in the fraction of individuals choosing “none.” Thus, the increase in the share of individuals purchasing generic after the WTP increase was more than enough to offset the decrease in the share of individuals choosing not to purchase Choice.

The bottom of table 4 further illustrates the results in revenue terms. A \$1 increase in WTP for Choice causes a \$0.30 reduction in expected revenue for generic, but a \$2.23 increase

in expected revenue from Choice. A Pareto improvement can be achieved in the sense that the gains to Choice are more than enough to offset the losses to generic, assuming there was a mechanism available to redistribute revenue. Another interesting observation is that while increasing Choice WTP by \$1 (or 1%) increases total steak revenue by more than \$1 (1%), the same is not true of generic. That is, it would have to cost less than \$1 to increase generic WTP by \$1 for such a demand expansion strategy to be economically feasible.

The last column of tables 3, 4, and 5 show the effects of introducing a “natural” steak to the market. From an industry perspective, the introduction of a “natural” steak expands overall steak demand from 46.19% to 66.68% and increases per choice revenue from \$3.13 to \$3.76 (e.g., the expansion effect dominates the substitution effect). The natural steak tends to draw its market share predominately from the higher quality Choice steak. After the introduction of the natural steak, the share of consumers choosing Choice falls about 25% whereas the share of consumers choosing generic falls less than 1%.

Conclusions

This paper considers the effects of demand expansion and new production introduction on consumer purchases of beef steak. Our results suggest that altering the demand for higher quality Choice steaks generates larger total steak revenues than altering the demand for lower quality generic steaks. We also find that the introduction of a natural product has overall positive impacts on total steak demand.

Our results have a number of implications. First, commodity check-off boards might consider targeted advertising campaigns which focus on specific qualities. In the case of beef, campaigns that focus on taste and eating away from home would tend to favor Choice over

Select (generic), and according to our results, will increase total steak revenue by a greater degree than expanding demand for lower-quality steak. There are a number of factors to consider prior to implementation of such a program. This study investigated the effect of a nonspecific increase in demand; we did not measure response to advertising. At this point, it is unclear whether it might be relatively more easy or difficult to increase willingness to pay for higher quality than lower quality. For example, the marginal cost of expanding willingness to pay for generic steaks might be smaller than the marginal cost of expanding willingness to pay for Choice steaks by an equivalent amount. Further, this study only considered demand expansion effects for steak, but cattle are comprised of numerous cuts and relative substitutability might differ dramatically for ground beef, for example, as compared to steaks. As a last consideration, it is important to consider the distributional consequences of such targeted advertising. To some extent cattle producers can alter genetics or productions strategies to change cattle quality; however, it is likely that some producers are better able to produce high quality than others. It would seem necessary that targeted advertising strategies be implemented with some kind of distributional funding mechanism that accounts for the inequities in returns generated from such targeted demand expansion.

Our results also have important implications for food businesses such as grocery stores and restaurants. Such firms have the ability to carry out in-store advertising and to introduce new products. A store introducing a “natural” product for example can expect reduced sales of existing cuts; however, results of this study suggest overall revenue will expand. Further, for firms interested in introducing new “natural” products, our results suggest most new customers will come from those that do not purchase and those that currently purchase higher quality steak. This information will likely be useful in formulating marketing strategies.

From a broader perspective, we believe this research illustrates the usefulness of investigating substitution patterns with purchased goods and the “none” option in choice experiments. As we show, different goods have different substitution patterns with the outside option. Those interested in increasing industry-level demand are likely to be interested in determining which goods are most substitutable with the no purchase option.

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Scenario 11 I would choose . . .	Steaks					
	Generic	Guaranteed Tender	Natural	USDA Choice	Certified Angus Beef	None of These
	\$6.75	\$7.88	\$9.00	\$5.63	\$7.88	
	↓	↓	↓	↓	↓	↓
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 1. Example choice experiment question

Table 1. Random Parameter Logit Estimates

Independent Variable	Mean	Standard Deviation
<i>Alternative Specific Constants</i>		
Generic(GEN)	4.711* (0.720) ^a	0.480 (0.446)
Guaranteed Tender (GT)	12.775* (1.579)	2.259* (0.736)
Natural (NAT)	9.053* (2.862)	2.450* (0.889)
USDA Choice (CHO)	12.595* (1.290)	1.583* (0.449)
Certified Angus Beef (CAB)	17.760* (2.536)	2.529* (0.626)
<i>Own-Price Effects</i>		
GEN Price	-1.222* (0.191)	
GT Price	-1.994* (0.262)	
NAT Price	-1.751* (0.562)	
CHO Price	-1.781* (0.191)	
CAB Price	-2.595* (0.404)	
Log Likelihood	-1086.0	
Number of Observations ^d	976	

Note: One asterisks (*) represents statistical significance at the 0.01 level or lower.

^aNumbers in parentheses are standard errors.

^dEach respondent answered 17 CE questions, 16 of which were used in the estimation.

Table 2. Estimated Random Parameter Covariance Matrix

	Generic	Guaranteed Tender	Natural	USDA Choice	Certified Angus Beef
Generic	0.230	0.921	-0.267	0.567	0.873
Guaranteed Tender	0.921	5.103	-3.907	1.259	3.543
Natural	-0.267	-3.907	6.003	1.411	-0.997
USDA Choice	0.567	1.259	1.411	2.506	3.152
Certified Angus Beef	0.873	3.543	-0.997	3.152	6.393

Table 3. Market Share and Revenue in Demand Expansion and New Product Introduction Simulations

	Simulation Scenarios					
	1	2	3	4	5	6
	Baseline	1% increase in WTP for . . .		\$1 increase in WTP for . . .		Addition of Natural Steak
Steak Type		Generic	Choice	Generic	Choice	
<i>Market Share</i>						
Generic	10.86%	11.32%	10.39%	28.63%	4.85%	10.50%
Choice	35.33%	35.14%	37.60%	28.08%	65.77%	10.77%
None	53.81%	53.54%	52.01%	43.28%	29.38%	33.32%
Natural	0.00%	0.00%	0.00%	0.00%	0.00%	45.41%
Total Beef	46.19%	46.46%	47.99%	56.71%	70.62%	66.68%
<i>Per-Choice Revenue</i>						
Generic	\$0.55	\$0.57	\$0.53	\$1.45	\$0.25	\$0.53
Choice	\$2.58	\$2.57	\$2.75	\$2.05	\$4.81	\$0.79
Total Beef	\$3.13	\$3.14	\$3.28	\$3.50	\$5.06	\$3.76

Table 4. Absolute Change in Market Share and Revenue from Base-Line Simulation

Steak Type	Simulation Scenarios				
	1% increase in WTP for . . .		\$1 increase in WTP for . . .		Addition of Natural Steak
	Generic	Choice	Generic	Choice	
<i>Market Share</i>					
Generic	0.46%	-0.47%	17.77%	-6.01%	-0.36%
Choice	-0.19%	2.27%	-7.25%	30.44%	-24.56%
None	-0.27%	-1.80%	-10.53%	-24.43%	-20.49%
Natural	-	-	-	-	45.41%
Total Beef	0.27%	1.80%	10.52%	24.43%	20.49%
<i>Per-Choice Revenue</i>					
Generic	\$0.02	-\$0.02	\$0.90	-\$0.30	-\$0.02
Choice	-\$0.01	\$0.17	-\$0.53	\$2.23	-\$1.79
Total Beef	\$0.01	\$0.15	\$0.37	\$1.93	\$0.63

Table 5. Percentage Change in Market Share and Revenue from Base-Line Simulation

Simulation Scenarios					
Steak Type	1% increase in WTP for . . .		\$1 increase in WTP for . . .		Addition of Natural Steak
	Generic	Choice	Generic	Choice	
<i>Market Share</i>					
Generic	4.24%	-4.33%	163.63%	-55.34%	-3.31%
Choice	-0.54%	6.43%	-20.52%	86.16%	-69.52%
None	-0.50%	-3.35%	-19.57%	-45.40%	-38.08%
Total Beef	0.58%	3.90%	22.78%	52.89%	44.36%
<i>Per-Choice Revenue</i>					
Generic	4.25%	-4.32%	163.66%	-55.34%	-3.30%
Choice	-0.37%	6.61%	-20.39%	86.48%	-69.46%
Total Beef	0.32%	4.79%	11.82%	61.66%	20.13%