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Does Price Signal Quality? Strategic Implications of Price as a Signal of Quality for the Case of Genetically Modified Food[1]

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Abstract

We add to the limited empirical literature on consumers' use of price as a quality signal by testing if the traditional downward-sloping consumption-price relationship fails to hold for GM products using data collected from a nationally representative mail survey featuring several hypothetical product choice scenarios. Statistical evidence is mixed across the three products investigated but suggests that survey respondents use price as a signal of the quality of GM products. Implications for firm strategy are discussed.

Keywords: Conjoint analysis, genetically modified food, pricing strategy, price-quality relationship

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Introduction

The mantra preached in nearly every introductory economics course is simple and universal – holding all else equal, when price goes up, consumption falls. However, this truism may not hold for scenarios more involved than those discussed in *Economics 101*. For example, when a consumer is not entirely sure of a product's quality because quality is highly subjective (e.g., fashion or art), novel (e.g., a new technology), or difficult to verify prior to purchase (e.g., credence attributes like organic or dolphin-safe certifications), consumers may turn to one or more signals – including price – to form quality perceptions.

Products containing genetically modified (GM) ingredients meet each of the aforementioned criteria, i.e., GM ingredients are novel, their presence is difficult to verify, and their impact on quality may be viewed differently across individuals with the same knowledge. This leads to additional difficulty for product managers attempting to formulate pricing strategy in the presence of more a complex quality signaling environment. The purpose of this article is to determine whether consumers might use price as a complex signal of quality when judging GM products and to discuss the strategic implications if consumers do use price to infer quality.

Economists have posed many theoretical models to predict whether price or some combination of price and another quality signal such as advertising can effectively signal product quality when consumers are not fully informed (e.g., Klein and Leffler, 1981; Wolinsky, 1983; Milgrom and Roberts, 1986) and to better understand how the introduction of price as a quality signal may impact the shape of consumer demand functions (Pollak, 1977) and alter the nature of market equilibrium (Balasko, 2003). Jones and Hudson (1996) developed a model of the price-quality relationship at different price levels and concluded that there is a critical price interval in which price is used as a signal of quality. However, the results of their paper exclude the role of price as a signal of quality at lower price levels. They suggest that the price above a critical price is used to signal quality while discounted prices are not.

While empirical tests are not as common as theoretical work in this area, several authors have explored the predictions of various signaling models by correlating objective quality assessments of various consumer goods with price, advertising and other signals of product quality within particular markets (Landon and Smith, wine, 1998; Nichols, cars, 1998; Esposto, cigars, 1998) or across several markets (e.g., Hjorth-Andersen, 1991; Caves and Greene, 1996). Caves and Greene (1996) show that quality-price correlations exist in many markets and that the level of correlation is higher for product categories that include more brands and is lower for convenience goods.

Although all these papers approached the issues differently, they each suggest that price acts as a signal of quality. However, most of these papers focus on the empirical relationship itself rather than the behavioral effects induced from the relationship. In other words, most of these papers analyze the relationship between observed price and objectively-measured quality rather than individual consumer's purchase decisions induced by particular combinations of price and non-price quality signals. For instance, Caves and Greene (1996) analyze the correlations between product quality and price using data from *Consumer Reports*, in which experts rate the quality of various products. Esposto (1997) analyzes the relationship between price and quality by estimating a hedonic equation in which price is explained by experts' product quality ratings. However, these papers do not analyze consumers' consumption choice as a function of price and non-price quality signals.

The social and private efficacy of GM technology in food production is an increasingly studied issue in food consumption research. Many studies have examined GM acceptance as a food safety issue because, for some people, the perceived safety of GM technology is unresolved. That is, for some, food produced with GM technology indicates low quality. However, others suggest that the application of GM technology in food production could decrease food expenditures, reduce production costs, improve food attributes such as nutritional content and limit environmental problems such as agricultural chemicals residues (the Institute of Food Science & Technology, 2004). For example, Baker et al. (2001) document consumer segments that believe GM technologies represent high quality in the corn flakes cereals market.

Individuals' perceptions of the risk associated with particular products vary by product and can be greatly influenced by emotion and other subjective factors. In fact, some researchers define risk perception as psychological interpretation of product properties (Rozin et al., 1986; Yeung and Morris, 2001). Hence, signals of food safety and other dimensions of quality enter into the consumer's decision calculus. In the case of GM technology, food safety is likely to be more subjective because the safety of its adoption does not meet with uniform perception across all segments of consumers, i.e., GM ingredients may horizontally differentiate the product, finding favor with some consumers and disfavor with others. This heterogeneity leads to a particularly interesting interaction with price, which is often used as a signal of quality. For consumers with an initial view that GM food is safe or beneficial, a higher price may reinforce this initial view of high quality and reinforce decisions to purchase the product despite the higher price. However, for consumers with an initial view of GM food as low quality, a low price may reinforce these low quality perceptions and nullify price discounts as a means of enticing product trial or expanding market share. Hence, the classical downward-sloping relationship between price and demand may be challenged.

This paper is concerned with the role of price as a quality signal in GM foods. To explore the price-quality relationship, we analyze data collected from the administration of a mail-based survey that featured a conjoint (stated-preference) instrument in which a national cross-section of consumers chose among differentiated bread, corn and egg products. Product attributes such as price, GM content level and negative and positive GM attributions for each product in a choice set were experimentally manipulated and randomly assigned across respondents.

These data are used to test the hypothesis that GM product prices act as quality signals and the hypothesis that the effectiveness of price as a quality signal differs by the type of product. The remaining structure of this paper is as follows. The next section describes the data and reports summary statistics. The following section explores the relationship between price and respondents' product choices from our survey. The final section summarizes and concludes. A technical appendix featuring detailed econometric analysis follows.

Data

The data were collected from a survey that was sent to 5,462 US residents nationally and to an over-sample of 710 residents from one of the authors' home state (Maine). Two thousand and twelve people from the general sample and 375 people from the home-state sample returned surveys for a response rate of 37% and 53%, respectively. In the econometric analysis, the responses were weighted to account for the over-sampling of the home-state residents.

The basic framework of the survey is as follows. First respondents answer several sections of questions that deal with food consumption, food technology and genetic modification. Then, respondents are presented with a choice set for a particular product (bread, frozen corn, and eggs) where each set features three options: the respondent's normal brand, a brand with 100% GM content, and brand with no GM content. Labels for the GM and non-GM product were presented and included information concerning relative price (cents more or less than normal brand), GM content, benefits or warnings associated with GM content, and the name of a firm or agency that certified the presence or absence of GM content. No label was presented for the respondent's normal brand; rather, the words 'your normal brand' were mentioned in a parallel fashion as a possible choice.

Respondents were asked to assume that their normal brand was produced with a particular mix of both GM and Non-GM ingredients; the exact percent of ingredients that respondents were told to assume came from GM sources was randomly assigned across respondents. Respondents were also told that all brands shared the same appearance, taste, texture, and smell.

After viewing the product choices and being reminded of their household budget constraint, respondents chose the most preferred option. Some respondents viewed one of the three product choice sets, some viewed two product choice sets and others viewed all three product choice sets with the number and order of viewing randomized across respondents. Usable responses include 1,336, 793 and 950 choices made for the bread, corn and eggs categories, respectively. The prices used in the survey ranged from 40 cents more to 40 cents less than the cost of a package of the normal product.

Table 1: Descriptive Statistics for Socio-Demographics (N=1,967)

	Summary statistics [a]			U.S. Census [b]		
	Average		%	Average		%
Gender		Male	45.0		Male	48.3
		Female	55.0		Female	51.7
Age	52			47		
No. of Children	0.6			0.9		
Household Income($)	63,000			57,000		
Education		0-11 years	5.5		0-11 years	19.6
		12 years	27.1		12 years	28.6
	15	1-3 years college	28.5	13	1-3years college	27.3
		College graduate	22.5		College graduate	15.5
		More than college	16.4		After college	8.9
Race		White	90.0		White	77.1
		Black	4.6		Black	12.9
		Hispanic or Spanish origin	2.2		Asian/Pacific Islander	4.5[c]
		Asian or Pacific Islander	1.9		Others	6.6[d]
		Others	1.4		Hispanic/Latino	12.5
Concern with GM		1- Not at all	5.2			
		2	9.8			
	3.7	3 – Somewhat	23.2		Not available	
		4	23.5			
		5 – Very	38.3			
Concern with Hormones		1- Not at all	4.0			
		2	6.7			
	4.0	3 – Somewhat	19.0		Not available	
		4	21.4			
		5 – Very	48.9			
Concern with Preservatives		1- Not at all	8.5			
		2	16.6			
	3.3	3 – Somewhat	31.0		Not available	
		4	19.9			
		5 – Very	24.0			

[a] The summary statistics are based on the modified data for the paper. The income data and education data were collected in ranges and midpoints of each range were used for the table. The concern ratings were for a Likert scale where 1 is 'Not at all concerned', 3 is 'Somewhat concerned, and 5 is 'Very concerned'.
[b] Source: U.S. Census Bureau, Census 2000.
[c] Asian or Pacific Islander includes Asian, Native Hawaiian and other Pacific islander.
[d] Others include all other respondents not included in the categories of White, Black, and Asian or Pacific Islanders.

Other elements of the survey provide considerable data that is used to improve the explanatory power of econometric models. Earlier portions of the survey required respondents to provide ratings of concern for GM and other food processing technologies and to rate a number of different potential benefits and risks associated with GM technologies. The final portion of the survey asks for respondents' gender, age, education level, race, income level, and household composition (see Table 1 for descriptive statistics). We do note that our sample features more females, is older, has fewer children in the household, is richer, has obtained more formal education, and features fewer minority respondents than the general U.S. population.

Several non-price product-specific attributes were also included on some product labels. Some randomly assigned GM products included the following health (environmental) warning statement: "Long-term health (environmental) effects are currently unknown." Some randomly assigned GM products featured claims stating that the product was genetically modified to improve either a health attribute (increased levels of antioxidants for bread and corn and reduced levels of cholesterol for eggs) or an environmental attribute (reduced pesticide use for bread and corn). All claims of GM content or absence were accompanied by a certifying statement endorsed by either a government agency, environmental organization, or an independent certification firm.

Table 2 features a summary of the product choices made by respondents. About half of the respondents chose the non-GM brand in each product category while about 20% chose the GM brand.

Table 2: Preferred Product in Choice Set

	Bread	Corn	Eggs
GM	242 (18%)	167 (21%)	165 (17%)
Non-GM	675 (51%)	406 (51%)	523 (55%)
Normal	419 (31%)	220 (28%)	262 (28%)
Total	1,336 (100%)	793 (100%)	950 (100%)

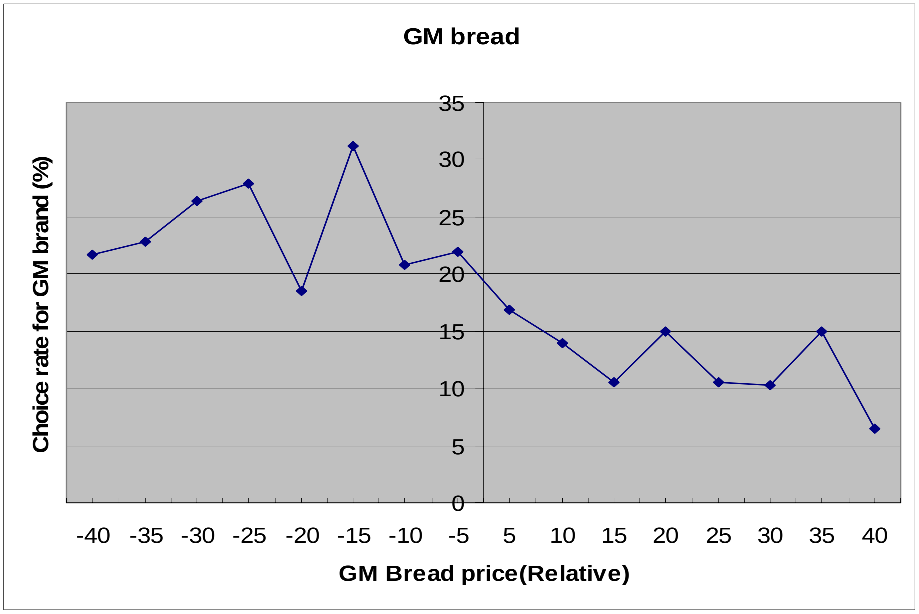

Figure 1: The Relationship between the Price of GM Bread and Respondents' Consumption Choice

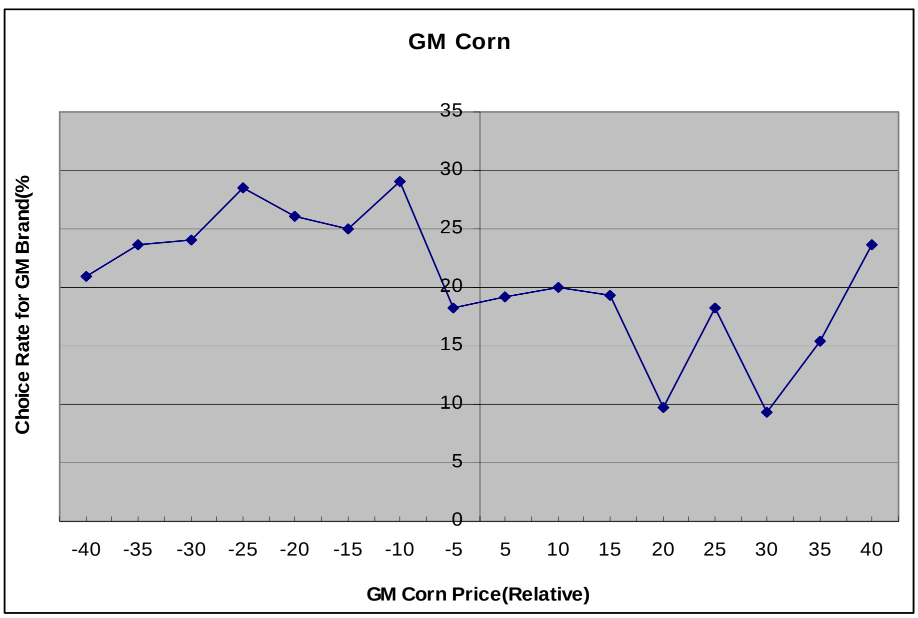

Figure 2: The Relationship between the Price of GM Corn and Respondents' Consumption Choice

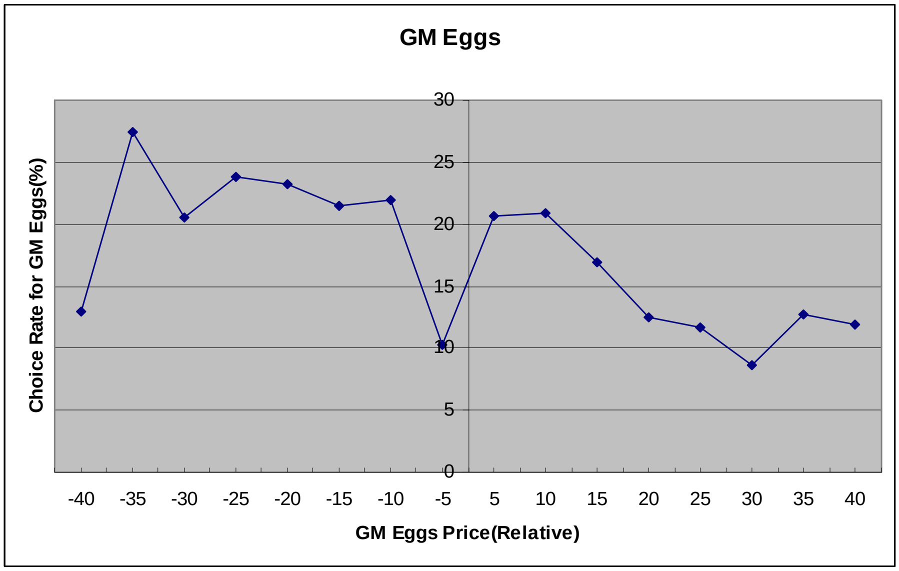

Figure 3: The Relationship between the Price of GM Eggs and Respondents' Consumption Choice

Results

The percent of respondents who choose the GM brand in each product category (call this the GM market share) is plotted for each price level used in the survey design (Figures 1 – 3). Because the other attributes of GM brand (e.g., health claims and warnings) are randomly assigned across respondents in a fashion that is not correlated with the relative price that is assigned, the average profile of the GM products for each relative price level is similar, meaning one can draw intuition from these simple plots.

None of the three graphs reveal a simple, linear, down-hill relationship between price and the resulting market share that one might expect. That is, lowering the price does not appear to guarantee an increasing market share for the GM good among our respondents.

For the bread product, there is a steady decline in market share for prices within 15 cents of normal brand's price (+/-). However, discounts deeper than 15 cents appear counter productive while price premiums in the 20 to 35 cent range appear to have a negligible effect on market share.

The corn product features a similar pattern with two slight differences. First, there is very little difference in market share responsiveness for prices that range from a nickel discount to a 15-cent premium. Second, the highest price premium was associated with the largest market share of any price premium, suggesting a possible role for high price as a positive quality signal.

The egg product is perhaps the closest to the traditional, down-hill relationship between price and market share. Two price discounts do appear to prompt strong negative reactions from the sample of respondents. The greatest discount offered in our survey – 40 cents – is associated with a marked reduction in market share as is the smallest price discount – five cents. Both suggest that respondents may use discounts as a signal of low quality, though the exact level of discount that can trigger such decisions can be large or small.

Taken together, these graphs indicate that some consumers may interpret prices below a certain threshold as a negative signal of quality (a "something must be wrong with it" heuristic) and choose other options. This pattern contradicts theoretical results forwarded by Jones and Hudson (1996) who suggested that only prices above a critical price premium are used for signaling quality (a "if its this expensive, it must be good" heuristic). The GM corn graph is supportive of the Jones and Hudson concept, as some of the largest market shares correspond with the highest prices.

A more formal, econometric test of the above intuition is conducted using respondents' choices in each product category and using other variables to control for potentially confounding explanations. A more detailed, technical report of the methods and results of that investigation is provided in the appendix.

The econometric results suggest that the simple down-hill relationship between price and market share is not present for most products and, for the one category in which it holds (bread), it is only statistically significant when crossing from discounts (prices that are less than the normal brand's reference price) to premiums (prices that are greater than the reference price). A more flexible model, which doesn't force the data to be fit to a regression line but instead allows the data to be fit to a regression curve, provides the best statistical fit for the corn category. In other words, the statistical results suggest that, once all the potentially confounding factors such as labeling treatments and respondent characteristics are controlled, price is not linearly related to market share. Rather, market share initially increases when moving from deep discounts to modest discounts, then declines as prices move from modest discounts to modest premiums, and finally increases once again prices move from modest premiums to larger premiums.

Conclusion

The purpose of this paper is to analyze how prices of GM products may act as quality signals and affect consumers' purchase decisions. Three products (GM bread, corn, and eggs) are analyzed using conjoint data generated from a national mail survey. Plots of the relationship between price and the share of consumers choosing GM products in each category suggest the relationship between price and market share may not adhere to a simple linear relationship where an increase in price decreases market share. Econometric analysis confirms that nonlinear relationships may best describe the relationship between price and respondents' choices of GM products.

This evidence suggests that consumers may use price as a signal of product quality when price deviates enough from the normal brand's price. Consumers' purchase intentions for GM bread increased as price declined modestly below the reference price down to a critical price level; after this price threshold, lowering prices had no real traction in increasing market share in GM bread. The plot of GM eggs showed little significant difference from general economic theory. That is, the price-demand relationship was linear and downward sloping over the whole price range. The only indication of the existence of price signaling quality was that the very largest and the very smallest price discounts were associated with marked reductions in market share. When combined with evidence from econometric models of respondents' choices of GM products, it suggests that respondents use the price of GM products as a signal of quality. Further survey work would need to be conducted where respondents are specifically asked to rate perceived product quality after viewing price and non-price information for GM and non-GM products. Furthermore, one must realize that the current investigation used products that were not branded in other ways (e.g., with company or product-line brand names). The introduction of such information onto the label may change some of the results, giving either more or less latitude to enact pricing strategies featuring deeper discounts or greater premiums.

Food products with labeled GM ingredients are in an introduction (start-up) period of their life cycle in most product categories. Firms who try to gain public awareness for their products and to expand their market share might, for example, have to decide between a low introductory pricing strategy, a price matching strategy, or strategy that sets price higher than competing, non-GM brands. If consumers use price as a signal of quality, however, some of these pricing strategies might be less effective or disastrous in certain product categories. For the hypothetical GM corn product in our research, for example, firms pursuing a low-introductory price strategy may fight an uphill battle because respondents may interpret low prices as a negative quality signal and avoid the trial purchases necessary to spur current and future sales. Furthermore, if retailers unilaterally discount GM products (e.g., in order to clear shelves of slow-moving trial products), the discounting could send an unintended message to consumers that GM ingredients are of low quality. There exists a possibility that this might spill over to consumers' perceptions of other GM products as well.

Consumption patterns for GM products are likely to vary widely across different consumer segments, where each segment may hold distinct ideas concerning the value, efficacy and safety of GM ingredients. Hence, choosing a marketing strategy will not be a simple matter. In fact, applying a pricing strategy alone as a marketing strategy without considering consumers' characteristics might not be effective for expanding market share of GM products. Pricing strategies may need to be tailored to the type of retail outlet (e.g., high-end food emporiums versus discount chains) and coordinated with non-price quality signals (advertising and in-store promotions) and existing regulatory interventions (labeling or public position papers on the safety of genetically modified foods).

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Appendix

To estimate the factors that drive respondents' choices of GM versus non-GM products, an econometric model is estimated that links a respondent's decision concerning whether to choose the GM brand (instead of either their normal brand or the GM-free brand) to characteristics of GM product (including price), the price of a GM-free option, and characteristics of the respondent. The variables used to represent the GM product's and the respondent's characteristics are detailed in Table A1.

Table A1: Description of Variables for Logit model of GM Brand Choice

Variable Name	Description
Dependent Variable:	($i \in$ {B, C, E} where B=Bread, C=Corn, E=Eggs)
Choice_B, Choice_C, Choice_E	= 1 if respondents choose GM brand for product i = 0 if respondents choose other brands for product i
Independent Variable:	
DP_i	The price of the normal brand less the price of the GM brand in cents for product category i.
$D_{i,k}$	$D_{i,k}$ = 1 if the price of the normal brand in category i less the price of the GM brand in cents is in the range of $[k, k+5]$ for k = -40, -30, -20, -10, 5, 15, 25, 35; = 0 otherwise.
DP_i_SQ	$(DP_i + 40)^2$
DP_i_TR	$(DP_i + 40)^3$
$DPNGM_i$	The price of the normal brand less the price of the non-GM brand in cents for product category i
GOV	= 1 if certifying agency was a government agency = 0 otherwise
ENV	= 1 if certifying agency was an environmental agency = 0 otherwise
IND	= 1 if certifying agency was an independent certifier = 0 otherwise
BANTIA, CANTIA	= 1 if GM bread (BANTIA) and GM corn (CANTIA) claims to be more healthful due to heightened levels of antioxidants = 0 otherwise
BLTHA, CLTHA, ELTHA	= 1 if GM bread (BLTHA), GM corn (CLTHA), and GM eggs (ELTHA) have a health warning label 0 otherwise
BLTEA, CLTEA, ELTEA	= 1 if GM bread (BLTEA), GM corn (CLTEA), and GM eggs (ELTEA) have an environmental warning label = 0 otherwise
LBPREDA	ln(% reduction in pesticides used in growing wheat for GM bread + 1)
LCPREDA	ln(% reduction in pesticides used in growing GM corn + 1)
LEPREDA	ln(% reduction in cholesterol due to use of GM eggs + 1)
GMCONCERN	= 1 if respondent rated GM technology a '5' on a 5-point scale of concern, = 0 otherwise
OWNBEN	Respondent factor score relating to GM's benefits for consumers
PRODBEN	Respondent factor score relating to GM's benefits for producers
OWNCOST	Respondent factor score relating to GM's cost reductions for consumers
PRODCOST	Respondent factor score relating to GM's cost reductions for producers
BREADGM	Respondent's estimate of % of normal bread made from GM wheat
CORNGM	Respondent's estimate of % of normal corn made from GM corn
EGGSGM	Respondent's estimate of % of normal eggs made from GM eggs
MALE	= 1 if male, = 0 if female
RACE	= 1 if White, = 0 otherwise
AGE_30	= 1 if under 30 years old, = 0 otherwise
AGE_70	= 1 if over 70 years old, = 0 otherwise
ED16	= 1 if obtained a Bachelor's degree or more, = 0 otherwise
INC_L	= 1 if annual household income ≤ \$5,000, = 0 otherwise
INC_H	= 1 if annual household income ≥ \$95,000, = 0 otherwise
CHILD	= 1 if children present in household, = 0 otherwise

Our key hypothesis is that the price of the GM product might act as a signal of the product's quality to the respondent. So, relatively low prices for the GM product might signal low quality and cause consumers to reject it, while high prices might signal high quality and cause consumers to embrace it. If prices are not acting as a signal of quality, low prices should stimulate sales while high prices will depress sales.

The statistical challenge is how to test for this unusual correspondence between price and sales. Usually price enters as a single explanatory variable in econometric models, which implies a simple, linear relationship between sales and price – e.g., every dime increase in price will lead to the same reduction in sales.

This does not allow us to test for our key hypothesis. Therefore, we alter the standard model in two ways. First, in addition to using price as an explanatory variable in our econometric model, we also add in the square and cube of price (e.g., $price^2$ and $price^3$). An econometric model that uses the square and cube of price allows for a more flexible relationship between sales and price, e.g., sales could first increase with an increase in price (e.g., when going from deep discounts to modest discounts), then decline with an increase of price (e.g., for prices near competing brands), and finally increase with increases of price (e.g., for prices at a modest premium above competing brands). Using econometric methods, we can then test to see if the data reveals this non-linear relationship between sales and price.

Our second approach is to treat each price category separately within the econometric analysis. Therefore, we create eight categorical variables for each 10-cent price interval and include these variables in the econometric analysis. Using econometric analysis, we can then test for differences between pricing intervals. If the traditional price-consumption relationship holds, we should find that sales of products with discounts of, say, 40 and 35 cents, will be greater than sales of products with discounts of 25 and 30 cents, etc.

To statistically isolate the effect of price on sales, we must control for all other possible explanations that might drive a respondent's choice. Hence, we add explanatory variables that will control for the randomly assigned attributes of the GM product (claims and warnings), the randomly assigned price of the GM-free brand, and for respondent's attitudes toward GM technology and personal characteristics. Summary statistics for each variable is presented in Table A2.

The econometric approach that is used involves the estimation of a binomial logit model for each GM product of the form:

A1) $$Y^{*} = \alpha_0 + \Sigma\, \alpha_i F_i\,(p_{GM}) + \boldsymbol{X}'\beta + \varepsilon$$

where Y^* is a latent preference index that, when it is greater than zero, represents the intended purchase of the GM product (i.e., causes, Y, the observed variable, to equal one if the GM product is purchased and equal zero otherwise); α_0 is an intercept parameter; $F_i(\bullet)$ is the ith function of the relative price of the GM brand (p_{GM}); α_i is the ith parameter associated with the ith function of price; $\boldsymbol{X}$ is a vector of all independent variables except GM brand prices; $\boldsymbol{\beta}$ is a conformable vector of parameters; and ε is the error term. Two general forms of the $F_i(\bullet)$ functions were articulated in Table A2: one where dummy variables are created to represent eight different price categories and one where a polynomial in the price of the GM food is created (e.g., price^2 and price^3). The polynomial representation is $F_j^i = (DP + 40)^j$, where 40 is added to all relative prices of GM products, i.e., all prices are normalized to the lowest possible price offered, to avoid squaring a negative number.

The estimation results for each product are in Tables A3-A5. To test the hypothesis that the market share of GM products adheres to the classical downward-sloping pattern, the following hypotheses are formulated when price is represented by categorical dummy-variables:

A2) H_0: $\alpha_i > \alpha_{i+1}$ $\quad i = 1, 2, \ldots, 7$
H_1: $\alpha_i \le \alpha_{i+1}$ $\quad i = 1, 2, \ldots, 7$

A3) H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$
H_1: $\alpha_1 \ne \alpha_2 \ne \alpha_3 \ne \alpha_4 \ne \alpha_5 \ne \alpha_6 \ne \alpha_7 \ne \alpha_8$

A4) H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$
H_1: $\alpha_1 \ne \alpha_2 \ne \alpha_3 \ne \alpha_4$

A5) H_0: $\alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$
H_1: $\alpha_5 \ne \alpha_6 \ne \alpha_7 \ne \alpha_8$

The first hypothesis (A2) postulates seven separate inequalities where the parameter for each lower price category is strictly larger (i.e., more likely to induce the choice of the GM product) than the parameter for the higher, adjacent price category. Rejection of this hypothesis means that market share is not strictly downward sloping across adjacent pairs of price categories. The second hypothesis (A3) flips the approach by postulating that all price parameters are equal; rejection merely confirms all price points do not have the same effect on market share. Hypotheses (A4) and (A5) are limited versions of (A3) and test for insensitivity to price across all price discounts (α_1 - α_4) and all price premiums (α_5 - α_8). Hypothesis testing results for each product category are listed in Table A6.

Table A2: Summary Statistics for Variables of Logit model of GM Brand Choice

Variable Name	Average	Share (%)	MIN	MAX
Choice_B		18.0		
Choice_C		21.0		
Choice_E		17.0		
GOV		77.1		
ENV		4.8		
IND		7.1		
BANTIA		8.6		
CANTIA		7.2		
BLTHA		34.0		
CLTHA		33.8		
ELTHA		32.8		
BLTEA		33.4		
CLTEA		30.8		
ELTEA		34.4		
LBPREDA	2.01		0	4.62
LCPREDA	1.99		0	4.62
LEPREDA	2.14		0	4.62
GMCONCERN		37.7		
OWNBEN	-0.02		-3.87	2.99
PRODBEN	0.01		-3.76	2.80
OWNCOST	0.02		-4.57	2.63
PRODCOST	-0.01		-3.91	3.53
BREADGM	42.50		2	90
CORNGM	42.00		1	90
EGGSGM	41.50		1	90
MALE		45		
RACE		90		
AGE_30		9.8	18	29
AGE_70		17.5	70	93
ED16		22.1		
INC_L		4.2		
INC_H		16.3		
CHILD		32.5		

Table A3: Regression Results for Bread (binary logit) (N=1,336)

Explanatory Variable	Polynomial Approach		Dummy Variable Approach	
	Estimated Coefficient	t-ratio [a]	Estimated Coefficient	t-ratio [a]
Dependent Variable: Choice_B				
INTERCEPT	-2.61	-6.82***	-	-
DP_B	-0.02	-5.22***	-	-
$D_{B,-40}$	-	-	-2.14	-5.22***
$D_{B,-30}$	-	-	-1.97	-4.79***
$D_{B,-20}$	-	-	-2.37	-5.40***
$D_{B,-10}$	-	-	-2.34	-5.58***
$D_{B,5}$	-	-	-2.89	-6.51***
$D_{B,15}$	-	-	-2.93	-6.42***
$D_{B,25}$	-	-	-3.09	-6.70***
$D_{B,35}$	-	-	-3.16	-6.85***
$DPNGM_B$	0.01	1.90*	0.01	1.90*
GOV	0.44	1.65*	0.44	1.64
ENV	-0.37	-0.71	-0.33	-0.64
IND	-0.09	-0.23	-0.09	-0.21
BANTIA	1.06	3.81***	1.02	3.63***
BLTHA	-0.58	-3.07***	-0.57	-3.02***
BLTEA	-0.30	-1.64	-0.29	-1.61
LBPREDA	0.29	6.68***	0.30	6.64***
GMCONCERN	-0.60	-3.41***	-0.61	-3.45***
OWNBEN	-3.10E-03	-0.05	-0.01	-0.16
PRODBEN	3.47E-03	0.06	0.01	0.16
OWNCOST	-0.16	-2.54**	-0.16	-2.58***
PRODCOST	0.16	2.53**	0.16	2.57**
BREADGM	0.01	1.60	0.01	1.54
MALE	-0.03	-0.21	-0.04	-0.28
RACE	1.53E-03	1.52	1.61E-03	1.60
AGE_30	-0.82	-2.21**	-0.83	-2.26**
AGE_70	0.23	1.17	0.22	1.10
ED16	0.46	2.53**	0.46	2.53**
INC_L	-0.01	-0.05	-0.02	-0.11
INC_H	0.01	0.05	0.02	0.11
CHILD	-1.56E-03	-2.00**	-1.65E-03	-2.12**

[a] *, **, ***: significant at the ten, five, and one % level, respectively.

Table A4: Regression Results Corn (binary logit) (N=793)

Explanatory Variable	Polynomial Approach		Dummy Variable Approach	
	Estimated Coefficient	t-ratio [a]	Estimated Coefficient	t-ratio [a]
Dependent Variable: Choice_C				
INTERCEPT	-1.82	-3.55***	-	-
DP_C	0.05	1.64	-	-
DP_C_SQ	-1.89E-03	-2.00**	-	-
DP_C_TR	1.53E-05	1.95*	-	-
$D_{C,-40}$	-	-	-1.66	-3.46***
$D_{C,-30}$	-	-	-1.43	-3.01***
$D_{C, -20}$	-	-	-1.48	-2.93***
$D_{C, -10}$	-	-	-1.41	-2.91***
$D_{C, 5}$	-	-	-1.94	-3.76***
$D_{C, 15}$	-	-	-2.17	-4.30***
$D_{C, 25}$	-	-	-2.17	-4.00***
$D_{C, 35}$	-	-	-1.94	-4.03***
$DPNGM_C$	1.76E-03	0.48	1.87E-03	0.51
GOV	0.11	0.36	0.10	0.34
ENV	-0.22	-0.39	-0.26	-0.47
IND	-1.40	-2.09**	-1.45	-2.15**
CANTIA	0.59	1.65*	0.58	1.62
CLTHA	-0.66	-2.85***	-0.67	-2.85***
CLTEA	-0.26	-1.21	-0.26	-1.20
LCPREDA	0.24	4.81***	0.24	4.86***
GMCONCERN	-0.45	-2.08**	-0.45	-2.06**
OWNBEN	0.11	1.55	0.12	1.62
PRODBEN	-0.11	-1.55	-0.12	-1.62
OWNCOST	-0.14	-1.93*	-0.14	-1.88*
PRODCOST	0.14	1.93*	0.14	1.87*
CORNGM	-1.19E-03	-0.22	-8.68E-04	-0.16
MALE	0.28	1.44	0.29	1.50
RACE	-2.48E-05	-0.02	-6.94E-05	-0.06
AGE_30	0.04	0.10	0.03	0.07
AGE_70	0.31	1.22	0.30	1.18
ED16	0.33	1.53	0.32	1.50
INC_L	0.26	1.15	0.26	1.12
INC_H	-0.26	-1.16	-0.26	-1.12
CHILD	9.98E-04	0.66	1.02E-03	0.68

[a] *, **, ***: significant at the ten, five, and one % level, respectively.

Table A5: Regression Results for Eggs (binary logit) (N=950)

	Polynomial Approach		Dummy Variable Approach	
Explanatory Variable	Estimated Coefficient	t-ratio [a]	Estimated Coefficient	t-ratio [a]
Dependent Variable: Choice_E				
INTERCEPT	-2.11	-4.68***	-	-
DP_E	-0.01	-2.98***	-	-
$D_{E,-40}$	-	-	-1.78	-3.60***
$D_{E,-30}$	-	-	-1.82	-3.64***
$D_{E,-20}$	-	-	-1.70	-3.27***
$D_{E,-10}$	-	-	-2.18	-4.30***
$D_{E,5}$	-	-	-1.92	-3.80***
$D_{E,15}$	-	-	-2.32	-4.45***
$D_{E,25}$	-	-	-2.62	-4.81***
$D_{E,35}$	-	-	-2.47	-4.64***
$DPNGM_E$	0.01	2.91***	0.01	2.88***
GOV	0.45	1.32	0.46	1.34
ENV	0.06	0.11	0.07	0.12
IND	-0.23	-0.42	-0.23	-0.42
ELTHA	-0.21	-0.96	-0.21	-0.96
ELTEA	-0.42	-1.86*	-0.42	-1.87*
LEPREDA	0.20	4.35***	0.20	4.31***
GMCONCERN	-0.56	-2.80***	-0.56	-2.80***
OWNBEN	0.14	1.98**	0.13	1.89*
PRODBEN	-0.14	-1.98**	-0.13	-1.89*
OWNCOST	-0.15	-2.15**	-0.15	-2.15**
PRODCOST	0.15	2.15**	0.15	2.15**
EGGSGM	0.01	0.94	4.16E-03	0.83
MALE	-0.02	-0.08	-0.02	-0.10
RACE	8.02E-05	0.10	-4.93E-06	-0.01
AGE_30	-0.41	-1.20	-0.38	-1.10
AGE_70	-0.34	-1.29	-0.34	-1.27
ED16	0.01	0.06	0.02	0.11
INC_L	0.19	0.79	0.19	0.81
INC_H	-0.19	-0.79	-0.19	-0.81
CHILD	-1.69E-04	-0.20	-7.30E-05	-0.08

[a] *, **, ***: significant at the ten, five, and one % level, respectively.

Table A6: Likelihood Ratio Test Results

Hypothesis	i	Bread	Corn	Eggs	Critical Values
	1	0.39	0.45	0.02	
	2	2.16	0.02	0.14	
	3	0.01	0.04	1.87	
(3) H0: $\alpha_i > \alpha_{i+1}$ H1: $\alpha_i \le \alpha_{i+1}$ $i = 1,\ldots,7$	4	3.36*	2.08	0.54	3.84(5%) 2.71(10%)
	5	0.02	0.31	1.23	
	6	0.18	4.40E-05	0.57	
	7	0.43	0.32	0.12	
(4) H0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$ H1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8$		31.76**	9.94	11.39	[1.69, 16.01](5%) [2.17, 14.06](10%)
(5) H0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$ H1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4$		2.97	0.65	2.42	[0.22, 9.35](5%) [0.35, 7.81](10%)
(6) H0: $\alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$ H1: $\alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8$		0.81	0.64	3.44	[0.22, 9.35](5%) [0.35, 7.81](10%)

*,** signifies the hypothesis is rejected at the ten and five % level, respectively.

The null hypothesis in (A2), i.e., uniform downward-sloping demand across price categories, is rejected at the ten percent significance level for all adjacent price points of all products except for $i = 4$ in the bread category, which means that downward-sloping demand between the price categories of [-$0.10, -$0.05] and [$0.05, $0.10] cannot be rejected. For all other adjacent price points and all products, cheaper GM products are not significantly more likely to be chosen than ones slightly more expensive.

The null hypothesis of (A3), i.e., equivalence of the effect of all price categories on purchase decisions, is rejected at the ten percent significance level only in the bread category. It suggests that there is significant sensitivity of choice to price in the bread category but not much price sensitivity in the corn and egg categories. The null hypotheses of (A4) and (A5) refine the results by validating that, across all relative prices that share the same sign, there is no significant difference in market share's response across price categories. Taken together the test results suggest that a downward sloping relationship is not present for most products and, for the one category in which demand slopes downward in some price regions, it is only significant when crossing the threshold from prices that are greater than the normal brand's reference price to prices that are less than the reference price.

Despite a lack of price category by price category change in market share, a simpler regression featuring choice as a linear function of price may reveal the expected negative relationship. Therefore, a second approach to examining the slope of demand is used: we test for the significance of higher-order terms in polynomial representations of GM price, i.e., to see if the price^2 and price^3 terms are statistically significant. For the model of GM bread and GM egg choices, however, only the linear relative price variables (DP_B and DP_E) were significant; results featuring higher order terms are omitted. DP_B and DP_E affected consumer choices of GM bread and eggs in negative manner, which is consistent with standard theory and suggests that the role of price in signaling quality is not strong enough to cause a curvilinear relationship between price and market share.

For the model of the GM frozen corn choice, the square and cube of the relative price of GM corn are significant (DP_C_SQ and DP_C_TR, respectively). This suggests the possibility of a significant, curvilinear change in the consumption pattern as price changes. At lower prices, the probability of choosing the GM corn decreases even if price is lowered further. However, the probability of choosing GM corn increases at higher prices when price is raised further. This retains the basic shape observed from the raw data plot in figure 2. The ability of such a cubic relationship to hold beyond the narrow price range explored is, of course, highly questionable. Minimally as price continues toward zero market share can go no lower than zero, while, at very high prices, market share will suffer.

Discussion

Taking the results from the price-category approach and the polynomial approach together, there appears to be some evidence that demand for the GM products does not uniformly decrease with price. The most convincing evidence exists for GM corn: both the dummy variable and polynomial approaches reject uniform, downward sloping demand. The weakest case exists for GM bread: the dummy variable approach suggests demand drops going from categories featuring price discounts to categories featuring price premiums and no higher-order terms are significant in the polynomial approach. An intermediate case exists for GM eggs: the dummy variable approach finds no case for downward sloping demand in price while the polynomial case finds no significance for higher-order terms.

While there is some evidence against a downward-sloping demand in price, one may argue that factors other than price-quality signals drive this lack of adherence to the classical case. One argument could be that respondents faced hypothetical choices and, hence, did not seriously weigh price when contemplating GM product choice. Indeed, such critiques of hypothetical questionnaires are common in the early literature concerning hypothetical choices. However, more recent research involving parallel hypothetical and market decisions suggests that analysis of hypothetical choices provide an unbiased view of individual preferences in many settings, particularly those involving familiar private goods, though estimates are typically noisier, i.e., individual parameter estimates have a greater variance (Louviere et al. 1999).

Our own data suggest that respondents did treat price variables seriously: the price of non-GM products, which are presented to the same respondents in the same manner, are significant in two of the three product regressions. This suggests that prices were impacting respondent decisions in a traditional way for non-GM goods. The category in which the non-GM price was insignificant was corn, which is also the category for which downward-sloping demand of the GM product was the weakest. All tolled this leaves a mixed though intriguing case for the possibility that respondents were using price as a signal of quality when evaluating GM products.

