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

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Abstract: When products are differentiated and quality is highly subjective (e.g., fashion or art), novel (e.g., a new feature), or difficult to verify prior to purchase (e.g., credence attributes), consumers may turn to price as a signal of quality. Products containing genetically modified (GM) ingredients meet each of these criteria, i.e., GM ingredients are novel, their presence is difficult to verify, and their impact on subjective quality may be viewed differently across individuals with the same knowledge. We add to the limited empirical literature on consumers' use of price as a quality signal by testing for non-monotonicity of consumer demand in price for GM products using data collected from a nationally representative mail survey featuring several hypothetical product choice scenarios. We find mixed evidence across three products for non-monotonicity of demand in price and argue the results suggest that survey respondents use price as a signal of the quality of GM products for at least one of the three products investigated. Implications for firm strategy and regulation are discussed.

Key Words: conjoint analysis, genetically modified food, pricing strategy, price-quality relationship

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1. INTRODUCTION

In the general economic theory of undifferentiated goods, price has a monotonic relationship with consumption – consumption decreases as price increases. When products are differentiated, however, price's monotonic relationship to consumption need no longer hold. In fact, when product quality is highly subjective (e.g., fashion or art), novel (e.g., a new feature), or difficult to verify prior to purchase (e.g., credence attributes), consumers may turn to one or more signals, including price, to form quality perceptions. Products containing genetically modified (GM) ingredients meet each of these 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.

Many theoretical models explore 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 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 level. They suggest that the price above a critical price is used to signal quality while the price below a critical price is 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 share a common thought in the sense that they concluded 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 price and 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.

Product quality attributes are highly dependent upon the type of product. For example, in the case of food, it could be taste, nutrition, color, and shape, while in the case of kitchen appliances it could be energy efficiency, power and design. This paper focuses on GM content as an attribute.

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 decreases 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). 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 monotonicity of the price-demand relationship 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 nationally representative 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 signal 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. Section 2 describes the data and reports summary statistics. Section 3 explains descriptive model which used for analysis. Section 4 shows empirical results of the analysis and Section 5 summarizes and concludes.

2. DATA

The data were collected from a survey administered by the Department of Resource Economics and Policy at the University of Maine in 2002. The mail survey was sent to 5,462 US residents nationally and 710 Maine residents. Two thousand and twelve US (non-Maine) residents and 375 Maine residents returned surveys for a response rate of 37 percent and 53 percent, respectively. Responses were weighted to account for the over-sampling of Maine residents. The basic framework of the survey is as follows. Three different products (bread, frozen corn, and eggs) were included and each product featured three options: the respondent's normal brand, a brand with 100 percent 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.

Earlier portions of the survey provide various characteristics concerning individual respondents including gender, age, education level, race, income level, household composition (including number and age of children) and attitudes and opinions toward GM technology (see Table 1 for descriptive statistics). Indeed, it showed similar characteristics with U.S. census except the distribution of race and education level.

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

	Summary statistics [a]		U.S. Census [b]	
	Average	%	Average	%
Gender		Male : 45.0 Female: 55.0		Male : 48.3 Female: 51.7
Age	52		47	
No. of Children	0.6		0.9	
Household Income($)	63,000		57,000	
Education	15	0-11 years : 5.5 12 years :27.1 1-3years college :28.5 College graduate:22.5 After college :16.4	13	0-11 years :19.6 12 years :28.6 1-3years college :27.3 College graduate:15.5 After college : 8.9
Race		White : 90.0 Black : 4.6 Hispanic or Spanish origin: 2.2 Asian or Pacific Islander : 1.9 Others : 1.4		White :77.1 Black :12.9 Asian or Pacific Islander : 4.5[c] Others : 6.6[d] (Hispanic or Latino : 12.5 White : 69.1

[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.

[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.

The survey also elicited respondents' opinions toward GM technology. Respondents were asked to rate their concern toward the use of GM technology in food production and processing by choosing a number from one to five with one implying "not at all concerned" and five implying "very concerned" (Table 2). The average concern on the GM technology was 3.7. More than half, but not all, of respondents rated their concern as 'somewhat' or 'very' concerned.

Table 2. Consumers' concern on the GM technology (N=1,967)

Technology \ Concern	1	2	3	4	5	Average Concern
GM	5.2	9.8	23.2	23.5	38.3	3.7
Growth Hormones	4.0	6.7	19.0	21.4	48.9	4.0
Preservatives	8.5	16.6	31.0	19.9	24.0	3.3

Respondents were also asked to rate their opinions on the importance of GM technology as a way to reduce consumers' and producers' costs and to rate the importance of GM technology as a way to deliver potential benefits to consumers and producers. Each respondent rated the importance of 16 potential benefits and 16 potential concerns related to GE foods on a five-point scale. A factor analysis was then used to distill these responses into four primary underlying factors influencing their responses to these 32 questions.

Table 3. Factor analysis results of respondents' rating of the potential of benefit and cost-reduction produced by GM technology (N=1,967)

	Consumers' Benefits	Producers' Benefits	Consumers' Costs	Producers' Cost
Average	-0.02	0.01	0.02	-0.01
Max	2.99	2.80	2.63	3.53
Min	-3.87	-3.76	-4.57	-3.91

Table 3 lists descriptive statistics for these four factors, which feature a population average near zero by design. This helps categorize each respondent's attitudes toward GM technology as one that is positive or negative toward a view that the technology can help reduce costs for consumers and producers and bring benefits to producers and consumers.

Respondents also estimated the proportion of GM ingredients that they thought currently existed in processed foods currently on the shelf in US supermarkets. This number was later used to construct product-specific proxies for each respondent's perception of the percent of GM ingredients in their normal brand of each of the three products. Specifically, the respondent's reported estimate of the percent of GM ingredients in all processed food was averaged with the percent of GM ingredients in each of the three products to construct a proxy of the respondent's perception of the percent of GM ingredients in their normal brand of bread, corn and eggs (Table 4). This procedure basically assumes a simple Bayesian updating scheme on the part of the consumer where equal weight is given to both pieces of information. Other weighting schemes, including the sole use of only one piece of data, provided a poorer fit to the observed data, and are not considered.

Table 4. Estimated proportion of GM ingredients in normal brand (N=1,967)

	Bread	Corn	Eggs
Average	42.5	42.0	41.5
Max	90	90	90
Min	2	1	1

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 5 summarizes the product choices made by respondents. About half of the respondents chose the Non-GM brand in each product category while about 20 percent chose the GM brand.

Table 5. 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%)

3. MODEL

To estimate the factors that drive respondents' choices of GM versus non-GM products, a binomial logit model of the form

$$\Pr ob(Y=1|\mathrm{X})=\frac{e^{X'\beta}}{1+e^{X'\beta}}=\Lambda(X'\beta), \tag{1}$$

is employed, where Y is a binary categorical variable and where $Y=1$ when respondent chooses the GM brand and Y = 0 otherwise. Vector X contains the set of known factors that drive respondents' decisions, β is a conformable vector of parameters and, $\Lambda(\cdot)$ is the logistic cumulative distribution function. The parameters, which are estimated via the maximum likelihood method, dictate the probability of choosing the GM brand over alternative brands for the set of characteristic X. The

Table 6. Description of Variables for Logit model of GM brand choice

Variable Name	Description
Dependent Variable:	(i=B, C, and E; 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*, where $i \in$ [B, C, E] for bread, corn and eggs, respectively.
$D_{i,\,k,}$	$D_k = 1$ 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*, where $i \in$ [B, C, E] for bread, corn and eggs, respectively
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

Table 7. 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		

individual-specific data and product-specific variables included in the vector *X* are detailed in Table 6. Note that several approaches are used to capture relative prices. Summary statistics for each variable is presented in Table 7.

4. RESULTS

Visual Inspection of Share Data by Relative Price

As an initial investigation of the price-quality relationship, the percent of respondents who choose the GM brand in each product category (also referred to as GM market share) is plotted for each price level used in the survey design (Figure 1a, 1b, 1c). Because the other attributes of GM brand (e.g., health claims) 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 should be similar, meaning one can draw intuition from these simple plots.

The graphs show a non-monotonic pattern between price and respondents' choices for all products. That is, the market share for the GM good among our respondents is not monotonically decreasing in price, and this motivates our inquiry of price as a quality signal for the GM technology.

Also, the graphs show that the deviation from the normal monotonic patterns differs across products. For example, the graph for GM bread shows that market share decreases as price increases at higher price levels. This is similar to the standard theory in which demand decreases as price increases. However, market share increases as relative price increases for price levels below that of their normal brand. This might indicate that consumers interpret prices below a certain threshold as a negative signal of quality for GM bread (the "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 threshold are used for signaling quality (the "if its this expensive, it must be good" heuristic). A similar pattern is observed in the case of GM corn. In the case of GM corn the graph shows that consumers react to a possible quality signal not only at lower price levels but also at the highest price levels. Market share more strictly adheres to a monotonically decreasing function of price in the case of GM eggs. Although there are some indications that prices act as quality signals at extreme levels of price, the visual evidence from the graphs is less convincing.

Figure 1a. The relationship between the price of GM bread and respondents consumption choice

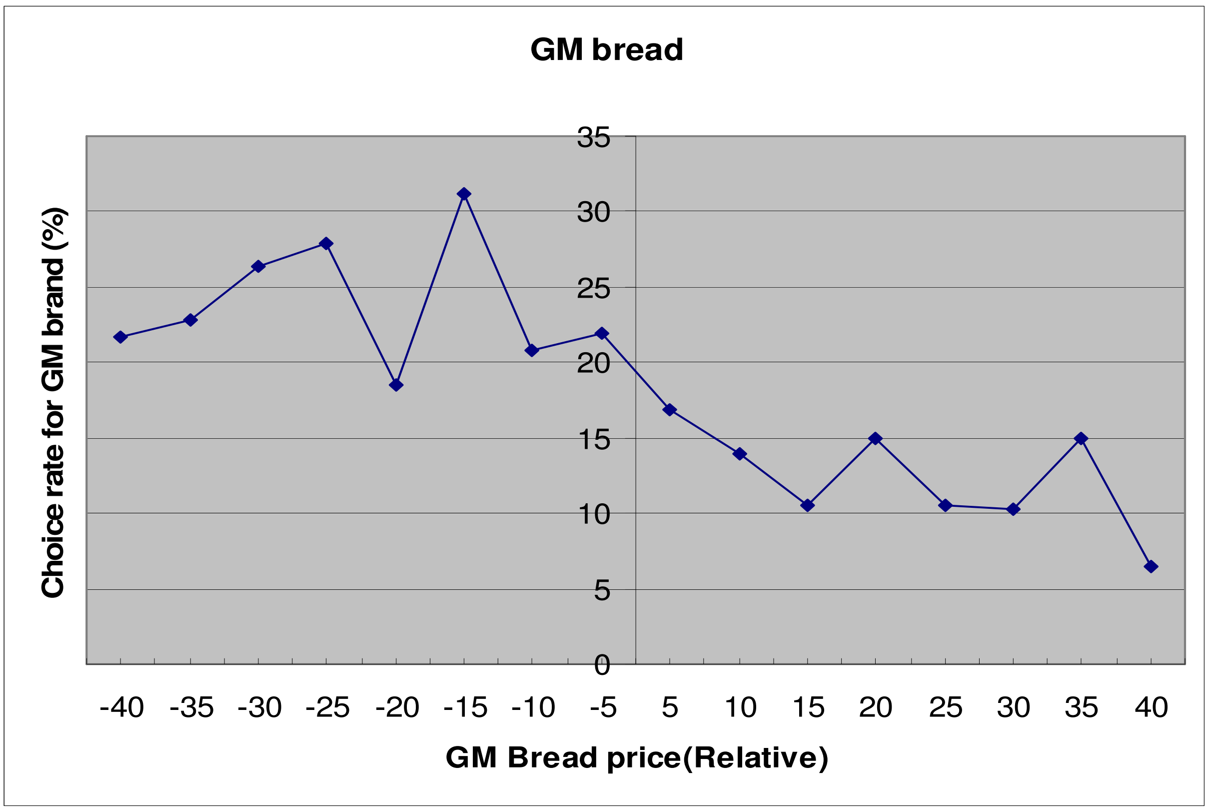


Figure 1b. The relationship between the price of GM corn and respondents consumption choice

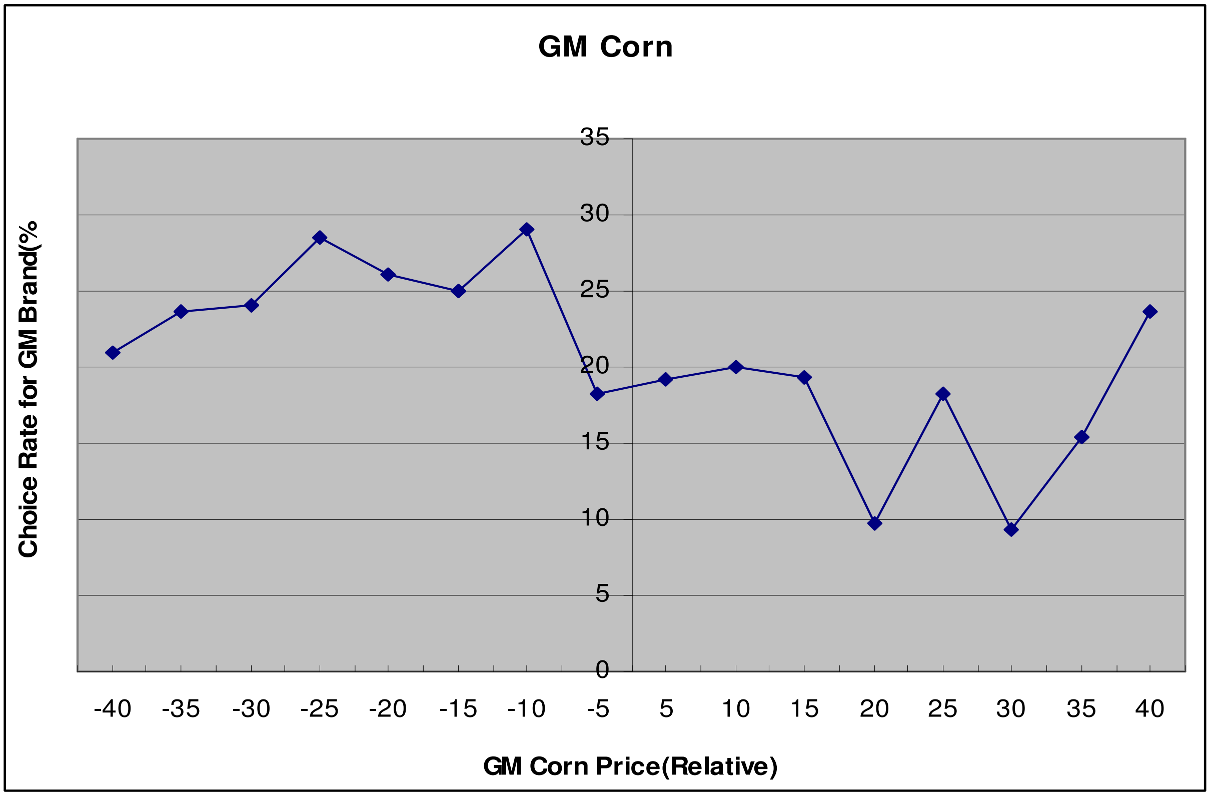
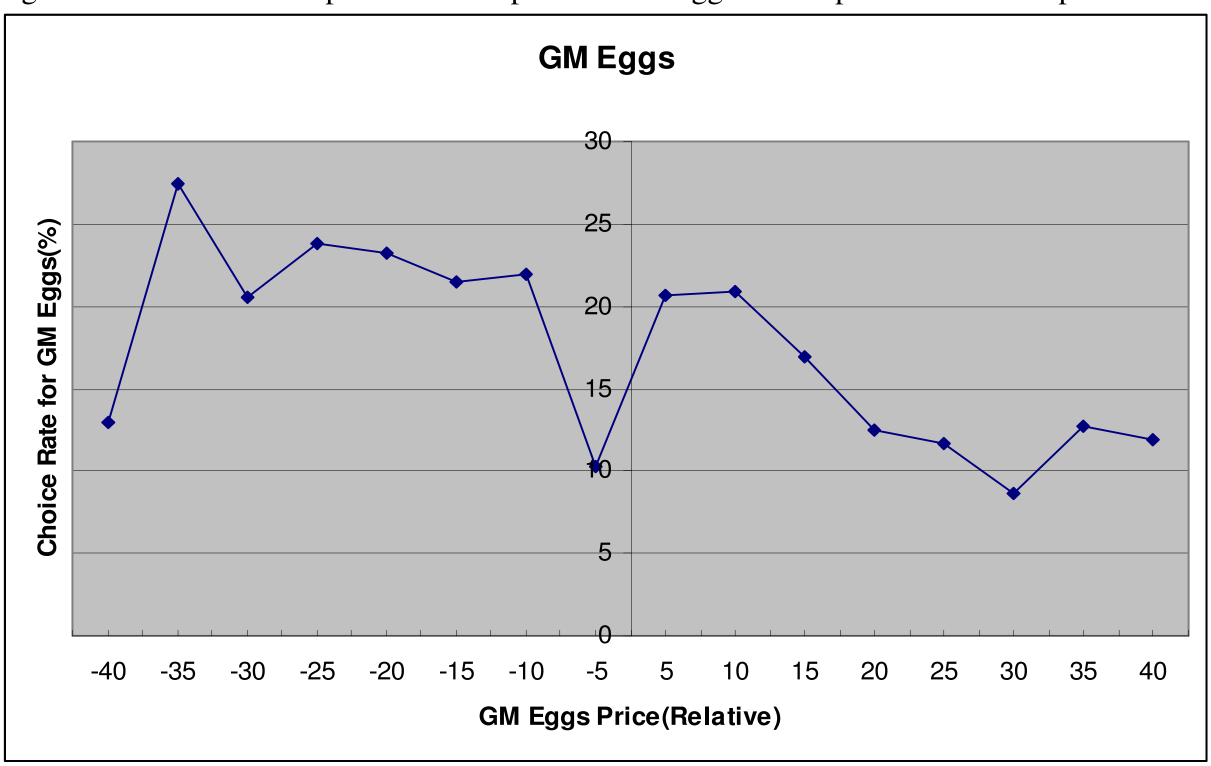


Figure 1c. The relationship between the price of GM eggs and respondents consumption choice



Econometric analysis

To formally test the trends that appear in the simple graphical exploration of market shares by price, a binomial logit model is estimated for each GM product of the following form:.

$$Y^* = \alpha_0 + \sum_{i=1}^{n} \alpha_i F_i(p_{GM}) + X'\beta + \varepsilon \qquad (2)$$

where Y^* is a latent preference index that, when it is greater than zero, triggers 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; X is a vector of all independent variables except GM brand prices; β 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 6: 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. The polynomial representation is $F_j = (DP + 40)^j$, 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 8-10. To test the hypothesis that the market share of GM products is monotonic in price, the following hypotheses are formulated when price is represented by categorical dummy-variables:

H_0: $\alpha_i > \alpha_{i+1}$ H_1: $\alpha_i \le \alpha_{i+1}$ $i = 1, \cdots, 7$ (3)

H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$ (4)

H_1: $\alpha_1 \ne \alpha_2 \ne \alpha_3 \ne \alpha_4 \ne \alpha_5 \ne \alpha_6 \ne \alpha_7 \ne \alpha_8$

H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$ (5)

H_1: $\alpha_1 \ne \alpha_2 \ne \alpha_3 \ne \alpha_4$

H_0: $\alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$ (6)

H_1: $\alpha_5 \ne \alpha_6 \ne \alpha_7 \ne \alpha_8$

Table 8. 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 percent level, respectively.

Table 9. 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 percent level, respectively.

Table 10. 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 percent level, respectively.

Table 11. Likelihood Ratio Test Results

Hypothesis	i	Bread	Corn	Eggs	Critical Values
(3) H_0: $\alpha_i > \alpha_{i+1}$ H_1: $\alpha_i \le \alpha_{i+1}$ $i = 1, \cdots, 7$	1	0.39	0.45	0.02	3.84(5%) 2.71(10%)
	2	2.16	0.02	0.14	
	3	0.01	0.04	1.87	
	4	3.36*	2.08	0.54	
	5	0.02	0.31	1.23	
	6	0.18	4.40E-05	0.57	
	7	0.43	0.32	0.12	
(4) H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$ H_1: $\alpha_1 \ne \alpha_2 \ne \alpha_3 \ne \alpha_4 \ne \alpha_5 \ne \alpha_6 \ne \alpha_7 \ne \alpha_8$		31.76**	9.94	11.39	[1.69, 16.01](5%) [2.17, 14.06](10%)
(5) H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$ H_1: $\alpha_1 \ne \alpha_2 \ne \alpha_3 \ne \alpha_4$		2.97	0.65	2.42	[0.22, 9.35](5%) [0.35, 7.81](10%)
(6) H_0: $\alpha_5 = \alpha_6 = \alpha_7 = \alpha_8$ H1: $\alpha_5 \ne \alpha_6 \ne \alpha_7 \ne \alpha_8$		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 percent level, respectively.

The first hypothesis (3) 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 strict monotonicity of market share does not hold for a particular adjacent pair of price categories. The second hypothesis (4) 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 (5) and (6) are limited versions of (4) and test for insensitivity to price across all price points lower than the respondent's normal brand (α_1 - α_4) and all higher price points higher than the respondent's normal brand (α_5 - α_8). Hypothesis testing results for each product category are listed in Table 11.

The null hypothesis in (3), i.e., monotonicity, 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 monotonicity 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 (4), i.e., equivalence of the effect of all price categories on purchase decisions, is rejected at the ten percent significance level only in 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 (5) and (6) 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 monotonic relationship is not present for most products and, for the one category in which some monotonicity exists, 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 category-by-category monotonicity of market share in price, a simpler regression featuring choice as a linear function of price may reveal the expected negative relationship. Therefore, a second approach to examining monotonicity is used to test for non-monotonicity: we test for the significance of higher-order terms in polynomial representations of GM price. 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 non-monotonic 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 also significant (DP_C_SQ and DP_C_TR, respectively). This suggests the possibility of a significant, non-monotonic 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 1b. 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 dummy variable approach and polynomial approach together, there appears to be some evidence that demand for the GM products in non-monotonic in price. The most convincing evidence exists for GM corn: both the dummy variable and polynomial approaches reject monotonicity. The weakest case exists for GM bread: the dummy variable approach suggests monotonicity for price categories surrounding the reference price of the respondent's normal brand 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 monotonicity while the polynomial case finds no significance for higher-order terms.

While there is some evidence against monotonity of demand in price, one may argue that factors other than price-quality signals drive this lack of monotonicity. 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 literature. If this were the case we would also expect the price of non-GM products, which are presented to the same respondents in the same manner, to be ignored in respondents' decisions. However, in two of the three models, the price of the non-GM product appears as a significant influence on the decision of the respondent, suggesting 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 the case on non-monotonicity of GM demand in price was the strongest. 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.

5. 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 nationally representative mail survey. Plots of the raw relationship between price and the share of consumers choosing GM products in each category hint at a non-monotonic relationship between price and market share and an estimated binary logit model of choices supports the lack of monotonicty in two of the three product categories.

The plots of GM bread and GM corn suggest 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 no significant difference from general economic theory. That is, the price-demand relationship was monotonic over the whole price range. Hence, there was no obvious indication of the existence of price signaling quality.

Logit models of the respondent choice of the GM product as a function of price and other factors are used to formally test for non-monotonicity of demand in price. The strongest case for non-monotonicity in price appears for the GM corn product, while the weakest case exists for the GM bread. The logical link between non-monotonicity of demand for GM products in price and respondents' use of

GM product price as a signal of quality requires evidence that respondents properly weighed price data during the decision making process. Mixed evidence is found, with prices for the non-GM product being significant and of the expected sign in two of the three categories. In summary, the evidence is suggestive 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.

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 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.

Considering the consumption patterns of GM products are distinctively different between certain consumption groups, 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. Differentiated pricing strategies along with suitable non-pricing strategies (e.g., labeling) in connection with different marketing target would be desirable for firm.

There is some evidence that price acts as a quality signal and affects consumers' purchase decisions for some GM products along with other signals such as quality or safety related labeling.

Price signals alone often mislead consumers into thinking that the product is distinctly differentiated and has better quality compared to other products even if it is not entirely the case. On the contrary, consumers could interpret price signals that the product has lower quality than other products. Non-pricing strategies such as a labeling either help consumers to form proper ideas on GM products or mislead them more. There is asymmetric information between consumers and other parties such as government and producers (sellers) in GM product market. Consumers who differentiate between GM products and Non GM products in market generally do not have sufficient information to do. Hence, a pricing strategy without proper product regulation would have great profit incentives for a firm whose product price contains positive quality signals. Under the presence of quality signals by price, product standard regulation and labeling standard regulation of quality and safety are important to reduce the excessive incentives of sellers to exploit any information asymmetries.

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