Consumption Externalities, Information Policies, and Multiple Equilibria: Evidence for Genetically Engineered Food Markets

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by

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We provide evidence of consumption externalities for foods with genetically engineered ingredients. The probability of choosing bread made exclusively from genetically engineered wheat is significantly higher for individuals who perceive normal bread to contain higher levels of genetically engineered content. The magnitude and significance of the consumption externality depends upon the intensity and nature of individual concern about genetically engineered foods and upon prevailing information policies such as explicit warnings about potential health impacts of genetically engineered foods. The estimated preference structures result in an equilibrium level of genetically engineered ingredients that can be sensitive to the initial level of genetically engineered content in the general marketplace. We discuss possible regulatory implications of such preferences structures.

Key Words: Consumption externality, genetically modified foods, multiple equilibria, stated preference methods.

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At least 70 percent of processed food in the United States contains some genetically engineered ingredients (Chassy) while virtually no food sold in Europe is genetically engineered (Kalaitzandonakes and Bijman). Why do U.S. consumers seemingly embrace genetically engineered foods (GEFs) while European consumers rebuff these fruits of modern science? This difference in market share of GEFs has lead to contentious trade negotiations between the United States and the European Union (EU), to EU requirements that GEFs be explicitly labeled for GE content (General Accounting Office), and to the United States filing suit against the EU with the World Trade Organization to lift its moratorium against the approval of new GE crops (Knight).

This continental difference is usually chalked up to a fundamental divergence in preferences, e.g., Europeans simply prefer foods that have not been altered via genetic engineering, particularly in the wake of various food scares such as Mad Cow Disease where government officials' handling of the situation led to an erosion in public trust. We explore an alternative explanation for the transatlantic difference in the market share of GEF's: consumption externalities. Markets featuring consumer externalities can admit multiple equilibria, which makes policies that influence the approval process for genetically modified foods and consumer access to information about GEF's critical because such interventions could alter initial market availability of GEF's and, hence, the equilibrium achieved. That is, the transatlantic difference in GEF adoption may not be driven entirely by fundamental differences in consumer preferences, but by the interaction of policies and consumers' information processing tendencies that result in the different markets reaching different equilibrium despite both markets admitting a similar set of potential equilibrium points.

Consumption externalities can take several forms. Network externalities occur when one consumer's utility is directly heightened as others adopt the same product or standard (Katz and

Shapiro). Social status or stigma externalities arise when one consumer's utility is directly affected as behavior aligns with or deviates from the norms of a reference group (Akerloff). Information externalities imply that one consumer's decision may affect another consumer's decision by signaling privately held information (Banerjee; Bikhchandani, Hirshleifer, and Welch).

We are interested in this last form of consumption externality and hypothesize that consumers will use the market share of GEF's as an indicator of product quality. Such consumer behavior has been assumed in previous work. For example, Caminal and Vives, and Vettas, postulate that consumers use past data on sales levels (market shares or quantities) as a proxy for product quality and choose accordingly; Becker assumes individual consumer demand functions have aggregate demand as an argument; and Smallwood and Conlisk assume that consumers dissatisfied with their current brand choose new brands in proportion to existing brands' market share.

Several empirical studies attempt to verify the presence and importance of such interactions, e.g., Dufflo and Saez, retirement savings plans; Welch (and citations therein), security analysts' recommendations; Hellofs and Jacobson, consumer products; and Kim and Kwon, telephone service. Several experimental studies verify the presence of cascades and herding outcomes and refine the understanding of how the structure of the information environment affects individual learning and choice probabilities (e.g., Allsop and Hey; Anderson and Holt; Huck and Oechssler; Hung and Plott; Noth and Weber).

Our analysis of U.S. consumers' preferences for bread containing GE wheat reveals that a 'safety in numbers' information externality does exist in which the probability of choosing the GE bread is positively influenced by the consumer's perception of the current market share of

GE bread. However, the strength of this externality varies according to consumers' concern about GE technologies and by the use of product labels that warn consumers of the presence of GE content. Those with lower levels of concern about GE technology do not exhibit the externality unless exposed to warning labels while those with higher levels of concern exhibit the externality only in the absence of warning labels.

Furthermore, in support of recent theoretical work by Smith and Sorensen, and Kim, we find that heterogeneity across consumers' preference for GEF's mitigates the strength of consumption externalities so that the equilibrium level of GEF's chosen may be less sensitive to the initial market share as consumer heterogeneity increases. Simulation of the model reveals that the prevalence of genetically modified wheat in the bread market depends upon consumers' initial perceptions of its prevalence, which suggests that policies affecting such perceptions could substantially alter the equilibrium market share of GE wheat. Hence, we conclude that the equilibrium GEF market penetration in the U.S. may be influenced by consumer externalities and opens the door for transatlantic differences in GE adoption driven at least in part to such externalities.

Model

We start our modeling effort with a standard random utility approach, where consumer utility for a particular product is influenced by product price and attributes and where utility parameters may vary across the population according to individual differences in income and demographics. Following Karni and Levin, we augment this model with one non-standard element: consumer perception of the existing prevalence or market share of GEF's. Karni and Levin use a game theoretic approach to link indirect utility functions of this form to nonmonotonic demand functions like those sketched by Becker. The basic premise in these models is that consumers take aggregate market share as a signal of unobserved quality.

For our purposes, we hypothesize that the existing prevalence of GEFs acts as a signal of product safety and can create feedback between aggregate and individual demand. The individual logic behind the ‘safety in numbers’ externality was aptly summarized by a participant of one of the focus groups that preceded our data collection. Respondents were asked to react to the following statement: “*Estimates vary, but due to the mixing of GE and non-GE food sources, particularly corn and soybean oils, virtually every processed food product in the United States probably has at least a trace of GE ingredients.”* The respondent’s relieved reaction was "… *it’s [GE food] probably OK since it hasn't killed me yet*." We find that many consumers take widespread use of the good, in this case GEFs, coupled with a lack of publicity concerning negative outcomes, as a signal of product safety, which creates a positive feedback loop from general demand to individual consumer demand.

Fundamentally we postulate a micro-level information processing phenomenon; hence the consumer’s information set is likely to be crucial in determining the presence and form of the information externality. For example, if the consumer does not know about genetic engineering, the prevalence of GEF’s in the market may signal nothing concerning product quality. On the other hand, consumers who are aware and concerned about GE ingredients may be actively seeking signals to shape their perception and, ultimately, their personal decisions concerning GEF’s. This introduces the possibility that traditional information-based policies, e.g., publicity surrounding new product testing, content labeling or warning information, may be used to alter the degree to which externalities exist and possibly shape the direction of such externalities.

We postulate that the indirect utility of consumer i for good j is

(1) $V_j^i = V(\boldsymbol{p^i}, \boldsymbol{q}_j^i(\alpha_j^i, \boldsymbol{I}, \boldsymbol{c^i}), \boldsymbol{c}^i)$

where $\boldsymbol{p^i}$ is a vector of prices faced by individual *i*; $\boldsymbol{q}_j^i$ is individual *i*'s perception of a vector of quality attributes for good *j;* α_j^i is consumer *i*'s perception of the market share of product *j*, $\boldsymbol{I}$ is a vector of information policies, $\boldsymbol{c^i}$ is a vector of characteristics for individual *i*, including income. The technology that formulates quality judgments, $\boldsymbol{q}_j^i(.)$, is a household production process by which an individual combines her prior knowledge, cognitive abilities, time and the product specific information presented prior to the purchase decision to formulate a perception of product quality.

When faced with a set of *J* potential products, a consumer will choose the product providing the highest indirect utility. The recursion between aggregate demand occurs via α_j^i, where perceptions of aggregate market share may vary across individuals.

Data

During the summer of 2002, we administered a mail survey to a representative sample of 6,172 U.S. residents. The survey was administered with multiple mailings and with an incentive paid for completed, returned surveys. In total 2,285 people responded to the mail survey for 37 percent response rate (summary statistics in Table 1).

Respondents are first asked a number of questions concerning their general perceptions of food and food production and are asked to estimate the percent of all food sold in the U.S. that contains GE ingredients. Respondents then answer a number of detailed rating questions concerning the potential benefits and risks of GE foods. Respondents are then asked to respond to a hypothetical product choice scenario involving several brands of bread, where the brands differ with regard to the percent of the wheat used to make the bread that has been genetically engineered and the respondent is given information concerning the percent of wheat in typical brands of bread that are derived from genetic engineering.

While data observed from market transactions would be preferred for such analysis, the hypothetical choice questions allow for increased control compared to market data. In particular, the hypothetical choice scenario allows us to alter the information presented to the respondent concerning the market share of GEFs. With market data, individual consumers' perceptions of GEF market share are rarely available while true market share of GEFs will be confounded with time, as the market share of GEFs in the United States has risen steadily over the past decade. 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.).

Another alternative would have been to utilize experimental techniques involving real products and expenditures (Fox, Hayes, Shogren). Such an approach would also allow manipulation of information that would shape subject perceptions of baseline GE levels. Such approaches typically involve narrower subject pools, however, and purchasing situations (e.g., auctions) uncommonly faced by consumers.

Study Design

In the choice scenarios faced by our respondents, the two bread packages are differentiated in several ways (Figure 1). One bread package always proclaims that all the wheat in the bread was genetically engineered while the other product always certifies the bread as GE-free. Products are differentiated by price, which is expressed as the difference in dollars from the price of their normal brand. The product containing all GE wheat is further differentiated with respect to the level of health benefits (high anti-oxidant content or not) and environmental benefits (a reduction in pesticide application compared to the conventional product or not). The bread made from GE wheat is also differentiated with respect to warning labels; some feature no warning label, some feature a label warning that long-term health effects are unknown, while others warn that long term environmental effects are unknown. The entity that certifies any label claims is also altered across subjects with various government (U.S. Department of Agriculture, U.S. Food and Drug Administration, or U.S. Environmental Protection Agency) and non-government agencies (Organic Consumers' Association, Identity Preservation Program, American Heart Association) being employed. Finally, the respondents are informed of the percent of the wheat used in making the normal brand of bread consists of GE wheat.

The number and order of products[2], the attributes that differentiate the products (price, health and environmental claims and warnings); the entity labeling the products; and the level of GE content in the conventional food supply are subject to investigator manipulation and are randomized across respondents.

We hypothesize that the presence, direction and severity of the consumption externality is affected by a consumer's information set. Several instruments are developed along these lines. The first is a dummy variable that equals one for respondents who answered that the use of genetically modified ingredients caused them to be 'very concerned,' which is the highest level of concern on a five-point scale. Another set of instruments captures the nuances of each respondent's perceptions regarding the potential benefits and risks of GE foods. Each respondent rated the importance of 16 potential benefits and 16 potential concerns related to GE foods on a five-point scale. We used factor analysis to distill these responses into four primary

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[2] A subset of respondents views additional products, including eggs and frozen corn. We focus our analysis on bread because the most respondents viewed this product. Similar results concerning externalities were found in the egg product but not the frozen corn product.

underlying factors influencing their responses to these 32 questions.[3] One factor (*ownben*) is higher for those who perceive that GE foods may hold important benefits for food consumers while another factor (*prodben*) increases as respondents believe GE foods may hold benefits for food producers. A third factor (*ownrisk*) grows larger as the respondent perceives consumer risks associated with GEF's to be important while the fourth factor (*prodrisk*) is increasing as the respondent belief that GEF's hold important risks for food or the environment. Factor variables are continuous and are constructed in a manner that limits co-linearity.

Our proxy for the respondent's perception of the GE content in a normal brand of bread is the simple average of the manipulated value of this content level included in the survey instrument and the respondent's perception of the market share of GEFs in all products collected earlier in the survey instrument.

Empirical Analysis

By assuming a particular functional form and observing consumers' product choices, we can infer how product attributes, personal characteristics and market share of GEF's may affect indirect utility and, hence, market demand for GE and GE-free foods.

The model is first estimated as a multinomial logit with a functional form that is linear in the market share of GE product, product attributes, and interaction terms. Analysis suggested that the preferences for respondents expressing high concern about GE ingredients are distinct from those respondents with less prior concern about GEFs.[4] Separate models are estimated for each segment. For each segment's model, we test for the independence of irrelevant alternatives (IIA) that is implicit in the multinomial logit formation. For the low-concern segment, the Hausman-McFadden test statistic soundly rejects IIA ($\chi^2(43) = 81.34$, p-val < 0.001) while, for

[3] To conserve space, details of this procedure are omitted but are available from the authors.
[4] A likelihood ratio test of the equivalence of parameters for the two segments resulted in a test statistic of 114.22 ($\chi^2(86)$, p-val $= 0.02$).

the high-concern segment, the Hausman-McFadden test statistic fails to reject IIA ($\chi^2(43) = 16.73$, p-val = 0.99). We estimate a nested logit model for each segment discussed above.

The parameter estimates from the 'stem' and conditional 'branch' models of the nested logit are listed in Table 2 for the more concerned and less concerned segments. The stem models a respondent's choice between GE-free bread and the other alternatives while the branch models a respondent's choice between the all GE (All GE) bread and the respondent's status quo bread.[5] A significant consumption externality emerges in the branch estimate, where respondents who have shunned the GE-free option decide between the status-quo product and the All GE product.

The externality in the branch choice operates differently for the low and high concern segments. For those with low concern about GE technologies, the perceived market share of GE only affects product choice if the all GE product is accompanied by a health warning on its label. When the warning is provided, this segment of consumers is more likely to purchase the all GE bread;[6] without the warning, GE market share has no significant influence on purchase patterns. The magnitude of the effect is considerable: a one percentage point increase in the perceived market share of GE product has as large of an effect on the probability of purchasing the all GE product as decreasing the price of the product by about one cent (average wheat bread prices were about $1.45 nationally at the time of the survey).

For those respondents with high concern about GE technologies, higher ambient levels of GE increase the likelihood of choosing the all GE product only when no health warning is provided. In the absence of such warnings, a one percent increase in the level of GE content in the status quo bread had a similar effect on probability of purchasing the all GE bread as did a

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[5] Given a choice set of three products, only one alternative nesting structure is possible: Status Quo/Other, followed by GE-free/GE-enhanced. Such a nesting structure did not fit the data as well.

[6] A Wald test of the joint significance of $GEshare_{SQ}$ and $GEshare_{SQ}*Hwarn_{GE}$ yields a test statistic of 3.03 ($\chi^2(1)$, p-val = 0.08).

3.3 cent decrease in the bread's price. The provision of the explicit warning language on the label offsets the influence of higher perceived market shares of GE content.[7]

For the high concern group, there also exist some mild interactions between the ambient level of GE and attitudes toward GE technologies. Particularly, respondents who view GE technologies as primarily benefiting producers (*Prodben*) at the expense of increasing risks for consumers (*Ownrisk*) are less likely to take perceived market share of GE product as a quality signal that increases the choice of all GE bread. In the case of *Prodben*, this effect works by retarding both the stem decision, i.e., to choose a product other than the GE- free alternative, and the branch decision, i.e., to purchase the all GE bread.

Potential Aggregate Effects of Consumption Externalities

Analyses of the choice data reveal a statistically significant consumption externality. The purpose of this section is to identify if the magnitude of these effects is large enough to affect market equilibrium. Aggregate effects may not arise for two general reasons. First, the sheer magnitude of the effect may not be large enough to meaningfully shape equilibrium outcomes. Second, consumers might be so heterogeneous that the externality effect may be washed out by simple differences in preferences across consumers. This is exacerbated by the fact that the all GE bread is horizontally differentiated, i.e., features attributes related to short term healthfulness (antioxidant content) may not appeal to all consumers. Simply put, there may always be a core of individuals who will purchase each brand of bread, which lessens the impact of feedback from the general consuming public to individuals. The model features preference parameters that interact with individual characteristics, allowing the possibility of preference heterogeneity

[7] A Wald test of the joint significance of $GEshare_{SQ}$ and $GEshare_{SQ}*Hwarn_{GE}$ yields a test statistic of 0.22 ($\chi^2(1)$, *p*-val = 0.64).

across the population. Indeed, theoretical explorations of consumer externalities (Smith and Sorensen, Kim) have implicated individual heterogeneity as a means for lessening pathological or extreme aggregate outcomes (e.g., herding, multiple equilibria).

To explore the nature and degree of aggregate effects we conduct a simulation based upon the estimated preference parameters. The basic premise is to define a consumer population, set the characteristics of the all GE product, identify the prevailing information conditions (e.g., label warnings), and then use the estimated preference model to simulate market shares.

The key correspondence to identify is how market shares for each product respond to different initial levels of GE content in the normal brand of bread. The simulation would be equivalent to evaluating market shares for goods given that the GE-free and the all GE bread were simultaneously added to a market previously populated with brands of bread that contained a mixture of GE and non-GE wheat ingredients.

The long-run equilibrium depends upon how information about market shares of the GE free and all GE product become incorporated into future product decisions. For example, if the status quo brand does not alter its formulation over time (i.e., it maintains its original mixture of GE and non-GE wheat), and this is the information that consumers continue to rely upon as their information about the ambient level of GE content in the market place, then there will be no evolution of market shares over time. Alternatively, consumers may just be slow at updating their perception of the level of the prevailing GE content in the market place. We refer to this as the static or initial simulated response.

Alternatively, consumers may take as a signal of the ambient level of GE content the average level of GE content across all brands of bread and not just the status quo or normal brand. For example, if the status quo brand contain ½ GE wheat and obtained ½ of the market share while the all GE bread obtained 1/10 of the market share during that same period, then the new ambient level of GE content could be defined as ½ * ½ + 1/10*1 = 0.35. In such a case, which we will refer to as the dynamic simulation, ambient market share of GE content declines from 50 percent (because only the status quo bread existed before and that contained 50 percent GE content) to 35 percent, and future purchasing decisions would be based upon this updated figure of 35 percent. Such an updating scheme may require several periods before arriving at the long run equilibrium market share of GE content.

Another nuance of the simulation is the type of populations that is simulated. We consider both a homogeneous and a heterogeneous population. The homogeneous population contains only two types of individuals: replications of the average low concern individual and replications of the average high concern individual. The heterogeneous population will feature a heterogeneous low concern segment and a heterogeneous high concern segment. Each individual's characteristics will be drawn from a distribution of characteristics that matches the sample distribution for each segment observed in our collected data.

The simulation begins by generating a sample population of consumers and endowing them with a uniform perception of GE content in common brands of bread. We then define two alternative types of bread: one that is free of GE content and one that is entirely composed of GE wheat and differentiated with regard to how the GE content affects health and environmental dimensions. For each individual in the population we calculate the utility levels for each outcome of the stem decision (GE-free and other bread). If the individual has higher utility for bread with some GE content, we then calculate the utility levels for the all GE bread and their normal brand of bread. Evaluation of this conditional preference structure results in the assignment of the type of bread purchased by each simulated individual. Market shares are then calculated for each of the three types of bread. For the dynamic simulation, the ambient level of GE content in the marketplace is then updated by multiplying the market share of the all GE bread by 100 and adding it to the product of the GE level in the normal brand and the level of GE content in normal brands. This is repeated for 15 periods, which proves sufficient to identify a long-run equilibrium market shares.

Results

Static simulation of the homogeneous population reveals that market share is sensitive to the initial level of GE in the normal brand of bread (Figure 2-5).[8] In the absence of warning labels, low ambient levels of GE content in the normal brand of bread creates positive market share for the GE-free bread (Figure 2a). Specifically, the 37 percent market share is created by the high concern consumer segment, while the low concern consumer segment chooses the normal brand of bread.

At moderate levels of initial GE content (20 to 50 percent), consumers from both segments choose their normal brand of bread. Then, at higher levels of initial GE content, the positive consumption externality for the high concern consumers becomes strong enough and this segment chooses the all GE bread.

If a warning label is in place, it is the low concern consumer segment that is sensitive to the consumption externality (Figure 2b). In this case, the initial level of GE in the normal brand must exceed 85 percent before the low concern group chooses the all GE bread; at all other

[8] The following parameters are employed for all simulations: $Dprice_{GE}$ = 20, $Dprice_{GE\text{-}free}$ = 10, $Pestreduce_{GE}$ = 1.79, $Healthben_{GE}$ = 1, *Envwarn* = 0, *Concern* = 0.37, *Labelgov* = 1, *Labelenv* = *Labelindep* = 0. Average demographic values for the low (high) concern segment are: *Owncost* = -0.21 (0.41), *Prodcost* = -0.21 (0.38), *Ownben* = 0.02 (0.08), *Prodben* = -0.06 (0.11), *Highinc* = 0.13 (0.07), *Male* = 0.51 (0.35), *Race Other* = 0.075 (0.07), *College Ed* = 0.24 (0.18), $Age \leq 30$ = 0.10 (0.09), $Age \geq 70$ = 0.175 (0.18). The variables $GEshare_{SQ}$ and $Healthwarn_{GE}$ are examined within the figures provided. For the heterogeneous simulations, 5000 individuals are used.

levels the low concern segment continues to purchase their normal brand of bread. The high concern segment chooses GE-free bread regardless of initial GE content in normal brands.

The difference in market penetration of GE content between static and dynamic simulation assumptions is relatively small when no labels are in place (Figure 3, thick dashed and solid lines, respectively). In both circumstances, initial GE content of normal brands is positively correlated to the final GE content across all brands after the introduction of the GE-free and all GE product.

With labels in place, however, the static and dynamic market penetration of GE content is very different, particularly for higher levels of initial GE content. Under the assumptions of the dynamic simulation, GE content across all brands dwindles through time and, in long run equilibrium, approaches zero. Initially, low concern consumers, who exhibit a positive consumption externality with labels in place, will purchase the all GE product if the normal brand of bread contains high levels of GE content. However, high concern consumers always choose the GE-free bread, which drags down the average market level of GE content and works against the positive externality. So, if consumers steadfastly update their perception of GE content to reflect shifting market trends, the market share of the all GE bread slowly unravels as low concern consumers see the high concern consumers buy GE-free bread and, via the consumption externality, derive lower utility from the all GE product.

The results from static simulations based upon a heterogeneous population (Figures 4 and 5) are similar to static simulations from the homogeneous population: there exists sensitivity of market share to the initial level of GE content in the normal brand, both with and without labels.

The heterogeneous nature of the population results in less sensitivity of market share to the initial GE content, e.g., compare the drastic change in market share for the all GE bread at the

85 percent level on initial GE content for the homogeneous population (Figure 2b) to the gradual increase in observed in the heterogeneous population (Figure 4b). Also notice that all three brands of bread obtain positive market share for all initial levels of GE content within the heterogeneous population, while the homogeneous population can at most sustain only two brands (one for each segment). A final difference is that, under the dynamic simulation mechanics, aggregate market penetration of GE content is insensitive to initial levels of GE content in normal bread brands, regardless of the presence or absence of labels. This means that if consumers are diligent in their updating and continue to maintain a preference structure featuring the estimated magnitude of consumption externalities, the consumption externalities effect will, in time, be overshadowed by other aspects of consumer preferences.

Conclusions

Genetically engineered ingredients are a novel and potentially pervasive part of the food supply. A consumer's decision to purchase GEF's, particularly when the long term consequences of the content are only partially understood, may be influenced by how other consumers have already decided. Such a consumption externality leads to the potential of multiple equilibria, where the final adoption of GEF's depends upon the initial conditions of product introduction and the knowledge and information gathering tendencies of consumers.

Using data from a representative sample of U.S. consumers we identify a preference structure with a consumer externality in which respondents are more favorably disposed to purchasing novel products made entirely of GE ingredients if they believe the normal products in the market place also contain high levels of GE content. The presence of the externality depends both the respondent's level of concern about GE technologies and information placed upon products with GE content. Consumers with lower levels of concern do not display an externality unless exposed to a label highlighting that the long term health consequences of GE ingredients in unknown. Consumers with higher levels of concern feature a similar externality if no label warning is provided, i.e., those with low concern who are provided a warning label act similarly to those of high concern who are provided no label. When consumers of high concern are exposed to such labels the externality is essentially eliminated.

We confirm theoretical predictions from previous work in consumption externalities and find that aggregate equilibrium for heterogeneous populations is less sensitive to initial conditions than for homogeneous populations. Furthermore, we find that if consumers regularly and accurately update their beliefs concerning the ambient level of GE content and continue to maintain the same preference structure over time, then the long run equilibrium generated by heterogeneous populations in unaffected by the initial market penetration of GE content.

These findings lead us to question the common explanation for divergences in GE market penetration between the U.S., a leading adopter and consumer of GEF's, and Europe, where few GE crops are grown and virtually no GEF's are consumed. The common explanation is that European consumers simply have weaker preferences for GE food. We conjecture that consumer externalities may help explain this difference.

A rough sketch of such an argument goes as follows. In the United States genetically modified ingredients gained substantial market penetration into processed foods prior to much public scrutiny. Once consumers became aware genetic engineering and food, GE ingredients were in widespread use, and consumers took this as a sign of safety, or paraphrasing one focus group participant, if nobody had died and GEF's were that pervasive, how bad could it really be?

Europeans, on the other hand, could have a similar preference structure as Americans, but had become aware of GEF's quite early in the diffusion process. Hence, with little product on the market, they had less confidence that GEF's would not cause harm, i.e., the consumer externality did not have enough existing market share to help spur further consumer purchases.

While such a story is plausible and intriguing, our data cannot directly test its accuracy. Nonetheless, it highlights the potentially critical nature of regulation during early product testing and sale. If consumer externalities of the type identified in the paper are strong, it suggests that product introduction with little fanfare could allow enough product penetration that, once scrutiny is applied to the product or innovation, that adoption may be more rampant. Higher levels of scrutiny triggered by a labeling scheme could have mixed results, with some consumers turning to other signals to validate potential concerns (e.g., looking to aggregate market share as a signal), while other consumers will simply not accept a product with such labels.

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Table 1. Summary Statistics (N=1108)

Variable		Mean	Std. Dev.	Min	Max
GE-free bread chosen		0.51	0.50	0.00	1.00
Status Quo bread chosen		0.31	0.46	0.00	1.00
GE-Enhanced bread chosen		0.18	0.38	0.00	1.00
Respondent has high concern about GE food	*Concern*	0.33	0.47	0.00	1.00
GE-Enhanced bread price difference from status quo (¢)	$Dprice_{GE}$	-0.26	25.36	-40.00	40.00
GE-free bread price difference from status quo (¢)	$Dprice_{GE\text{-}free}$	-1.57	25.52	-40.00	40.00
ln(percent reduction in pesticide use compared to status quo + 1)	$Pestreduce_{GE}$	1.98	1.99	0.00	4.62
GE-Enhanced bread labeled as containing high levels of antioxidants	$Healthben_{GE}$	0.08	0.28	0.00	1.00
GE-Enhanced bread labeled as with long-term health warning	$Healthwarn_{GE}$	0.34	0.47	0.00	1.00
GE-Enhanced bread labeled as with long-term environmental warning	$Envwarn_{GE}$	0.33	0.47	0.00	1.00
Respondent perception of base market share of GE ingredients in status quo bread	$GEshare_{SQ}$	42.10	18.39	2.00	90.00
Owncost factor value	*Owncost*	0.01	0.98	-4.07	2.63
Prodcost factor value	*Prodcost*	-0.02	0.99	-3.31	3.52
Ownben factor value	*Ownben*	-0.01	0.98	-3.29	2.99
Prodben factor value	*Prodben*	-0.02	0.98	-3.63	2.57
Respondent answered during second wave of mailings	*Wave*	0.27	0.44	0.00	1.00
Respondent exposed to second product sequence	*Sequence2*	0.25	0.44	0.00	1.00
Respondent exposed to third product sequence	*Sequence3*	0.25	0.44	0.00	1.00
Respondent exposed to fourth product sequence	*Sequence4*	0.25	0.43	0.00	1.00
Respondent offered response incentive A	*IncentiveA*	0.24	0.43	0.00	1.00
Respondent offered response incentive B	*IncentiveB*	0.28	0.45	0.00	1.00
Respondent offered response incentive C	*IncentiveC*	0.25	0.43	0.00	1.00
Bread label certified by a government entity	*Labelgov*	0.77	0.42	0.00	1.00

Bread label certified by an environmental group	*Labelenv*	0.05	0.22	0.00	1.00
Bread label certified by an Independent group	*Labelindep*	0.08	0.26	0.00	1.00
Respondent's household income greater than $175,000	*Highinc*	0.11	0.31	0.00	1.00
Male respondent	*Male*	0.46	0.50	0.00	1.00
African American respondent	*Black*	0.03	0.18	0.00	1.00
Respondent race not Caucasian or African American	*Race Other*	0.07	0.25	0.00	1.00
Respondent has a college degree	*College Ed*	0.23	0.42	0.00	1.00
Respondent 30 years old or less	*Age ≤ 30*	0.10	0.30	0.00	1.00
Respondent 70 years old or more	*Age ≥ 70*	0.15	0.36	0.00	1.00

Table 2. Conditional Utility Models for Bread Purchase.

	Low Concern about GEFs				High Concern about GEFs			
	Stem: Other vs. GE-free		*Branch: GE-enhanced vs. Status Quo*		*Stem: Other vs. GE-free*		*Branch: GE-enhanced vs. Status Quo*	
	Estimate	p-val	Estimate	p-val	Estimate	p-val	Estimate	p-val
$Dprice_{GE}$	-0.006	0.08	-0.024	<0.01	-0.001	0.83	-0.022	0.09
$Dprice_{GE\text{-}free}$	0.014	<0.01	na[a]		0.007	0.21	na	
$Pestreduce_{GE}$	0.152	<0.01	0.294	<0.01	0.233	<0.01	0.830	<0.01
$Healthben_{GE}$	0.655	0.04	1.530	<0.01	0.684	0.16	1.563	0.22
$Healthwarn_{GE}$	-0.826	0.05	-1.489	0.02	-0.444	0.60	1.077	0.63
$Envwarn_{GE}$	-0.424	0.04	-0.013	0.96	-0.539	0.09	-0.878	0.22
$GEshare_{SQ}$	-0.005	0.38	-0.008	0.36	0.012	0.26	0.073	0.01
$GEshare_{SQ}$ $*Hwarn_{GM}$	0.005	0.63	0.029	0.04	-0.004	0.80	-0.053	0.24
Ownrisk $*GEshare_{SQ}$	-0.005	0.29	-0.005	0.46	-0.022	0.05	-0.050	0.09
Prodrisk $*GEshare_{SQ}$	-0.002	0.69	-0.001	0.92	-0.007	0.44	0.030	0.12
Ownben $*GEshare_{SQ}$	0.003	0.58	0.005	0.54	-0.003	0.70	-0.006	0.75
Prodben $*GEshare_{SQ}$	0.009	0.08	-0.001	0.88	0.008	0.35	-0.045	0.07
Owncost	-0.201	0.36	-0.032	0.91	0.233	0.62	1.128	0.43
Producercost	-0.250	0.26	0.001	0.99	-0.319	0.41	-1.435	0.12
Ownbenefit	0.159	0.52	0.083	0.81	0.608	0.07	1.247	0.17
Producer-benefit	0.007	0.98	0.277	0.39	0.072	0.86	2.735	0.02
Wave	0.195	0.29	0.321	0.25	0.212	0.49	-0.808	0.30
Sequence2	0.095	0.69	0.016	0.96	-0.413	0.33	2.538	0.04
Sequence3	-0.136	0.58	0.108	0.77	0.837	0.03	2.124	0.58
Sequence4	-0.056	0.82	0.084	0.81	0.480	0.20	0.532	0.27
IncentiveA	0.117	0.63	0.500	0.17	-0.440	0.27	1.027	0.20
IncentiveB	0.216	0.35	0.321	0.38	-0.310	0.41	-1.179	0.25
IncentiveC	0.042	0.86	0.098	0.79	-0.236	0.54	-1.086	0.65
Labelgov	0.429	0.12	0.268	0.54	0.594	0.19	0.573	0.04
Labelenv	-0.205	0.69	0.658	0.49	0.550	0.47	4.596	0.70
Labelindep	0.265	0.53	1.091	0.11	0.023	0.97	0.678	0.68
Highinc	0.107	0.67	0.127	0.73	0.864	0.13	0.472	0.81
Male	-0.108	0.53	-0.154	0.55	0.552	0.05	-0.166	0.45
Black	-0.170	0.75	-0.237	0.77	-0.349	0.58	1.504	0.35
Race Other	0.003	0.99	-0.764	0.25	0.291	0.61	-1.367	0.14
College Ed	-0.114	0.55	0.420	0.13	0.349	0.36	1.492	0.26
Age ≤ 30	-0.519	0.08	-0.555	0.32	-0.232	0.65	-1.595	0.24
Age ≥ 70	0.136	0.58	0.260	0.44	0.539	0.15	-1.050	0.03
Appalachian	0.059	0.90	0.103	0.86	-0.743	0.24	-3.727	0.72

	Low Concern about GEFs				**High Concern about GEFs**			
	Stem: Other vs. GE-free		*Branch: GE-enhanced vs. Status Quo*		*Stem: Other vs. GE-free*		*Branch: GE-enhanced vs. Status Quo*	
	Estimate	p-val	Estimate	p-val	Estimate	p-val	Estimate	p-val
New England	-0.044	0.87	0.264	0.49	-1.578	<0.01	0.377	0.84
Tristate	-0.659	0.10	0.376	0.56	-1.130	0.05	-0.279	0.64
Mid Atlantic	-0.428	0.23	0.308	0.56	-0.640	0.18	-0.492	0.82
South Atlantic	-0.153	0.59	0.604	0.16	-1.775	<0.01	-0.308	0.46
Gulf	0.227	0.59	-0.138	0.82	-1.271	0.04	-0.885	0.72
Plains	-0.164	0.59	0.337	0.43	-0.983	0.09	-0.504	0.78
Mountain	-0.429	0.27	1.706	<0.01	-1.605	0.05	0.652	0.33
Pacific	-0.285	0.43	0.542	0.27	-1.620	<0.01	1.244	
Intercept	-0.077	0.89	-2.571	<0.01	-0.990	0.28	-6.134	0.03
Ln(likelihood)	-446.80		-220.48		-186.19		-51.06	
Likelihood ratio[b]	124.42	<0.01	86.48	<0.01	111.17	<0.01	73.86	<0.01
% Correct Predictions	61.2		64.6		66.1%		59.0	
N	739		404		369		134	

a – Not applicable.

b – Tests null hypothesis that all covariates except the intercept terms are jointly equal to zero and is distributed as a $\chi^2(43)$.

Figure 1. Hypothetical choice question.

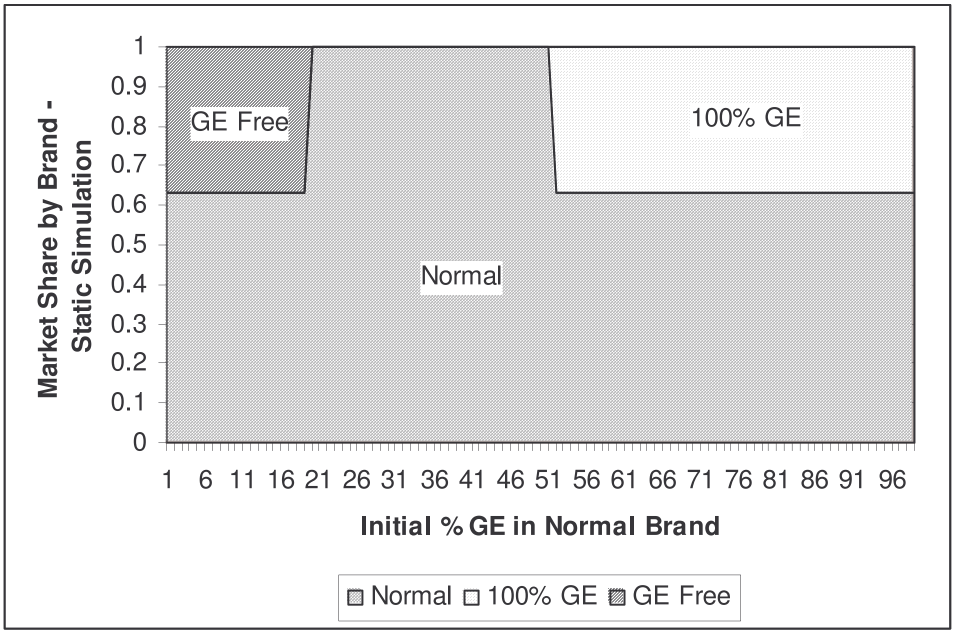
Assume that you went to your usual food store to buy a loaf of bread. In addition to a brand you have bought in the past, you find two other brands of bread. Each loaf of bread looks and smells the same. The only difference between the loaves of bread is what appears below. Note that farmers currently produce both genetically modified wheat and wheat that is not genetically modified. The company that makes your brand of bread mixes both types of wheat together. Please assume that 40% of the wheat in your brand of bread is genetically modified.

BRAND A Costs 10 cents less than your usual brand	**BRAND B** Costs 15 cents More than your usual brand
100% OF THE WHEAT IN THIS PRODUCT IS GENETICALLY MODIFIED Wheat genetically modified to reduce the need for pesticides. Wheat certified as grown with 30% fewer pesticides. Long-term health effects are currently unknown *certified by the US Department of Agriculture*	**CONTAINS NO GENETICALLY MODIFIED INGREDIENTS** *certified by the US Department of Agriculture*

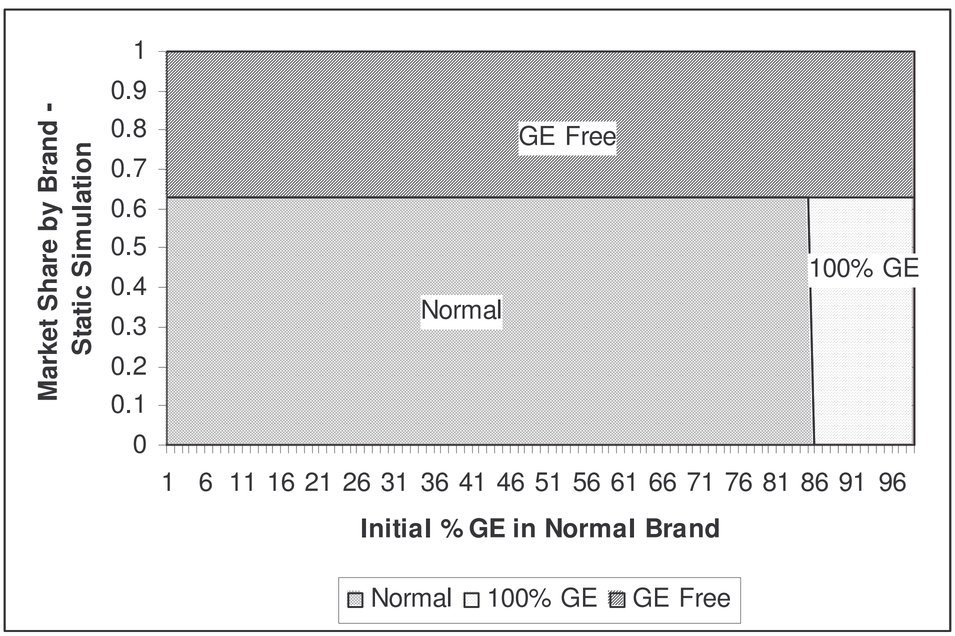
Which loaf of bread would you purchase? (CIRCLE ONE NUMBER)

1 I WOULD CHOOSE BRAND A
2 I WOULD CHOOSE BRAND B
3 I WOULD CHOOSE MY USUAL BRAND
4 I WOULD CHOOSE NOT TO BUY BREAD

Figure 2. Static Simulation Results – Homogeneous Population



(a) No Warning Labels



(b) With Warning Labels

Figure 3. Static and Dynamic Share of GE Content Across All Brands for a Homogeneous Population

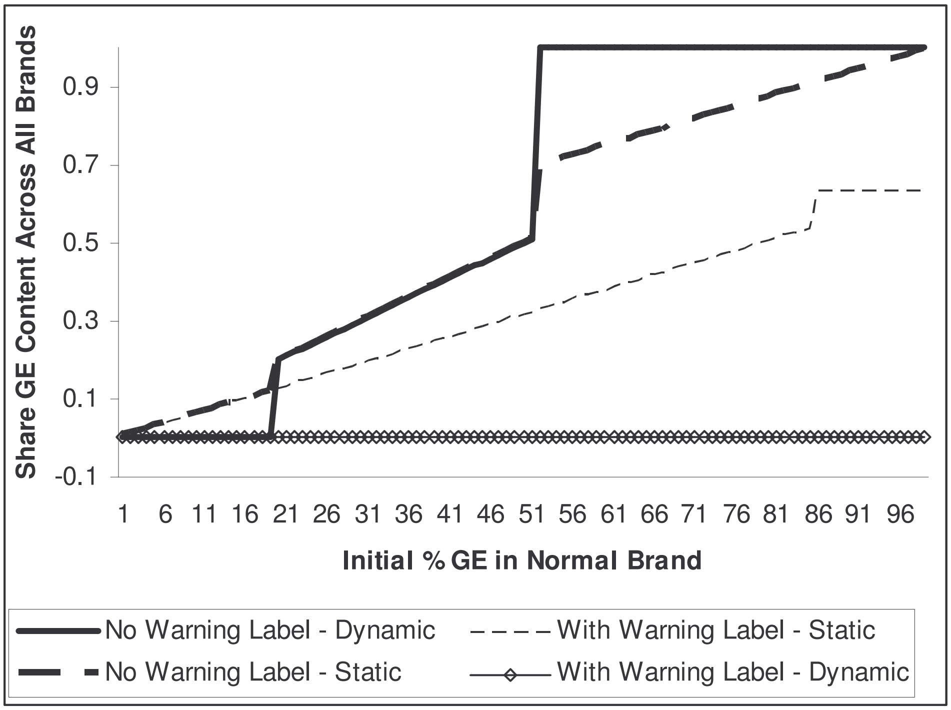
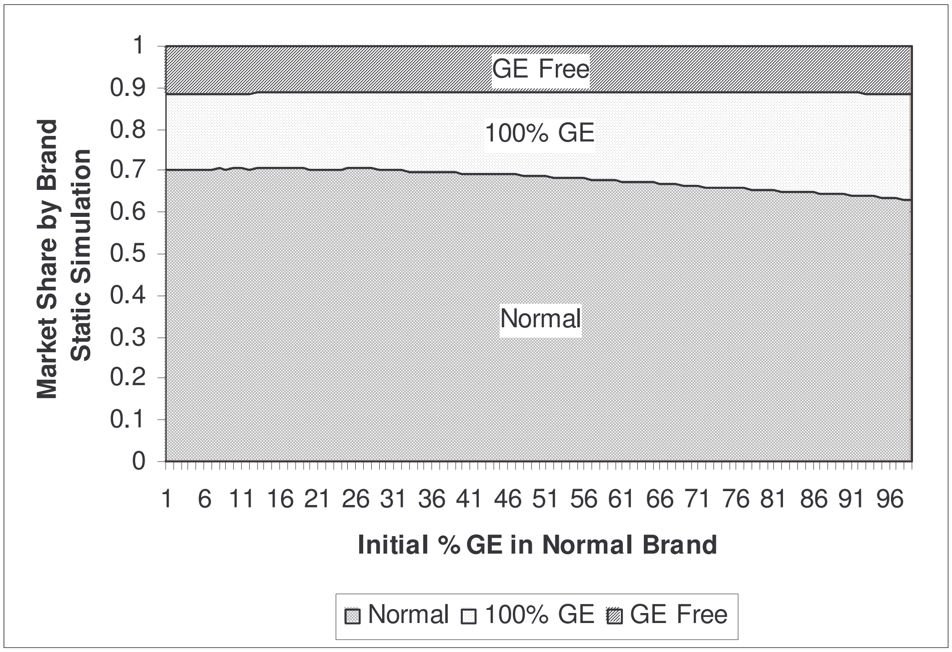
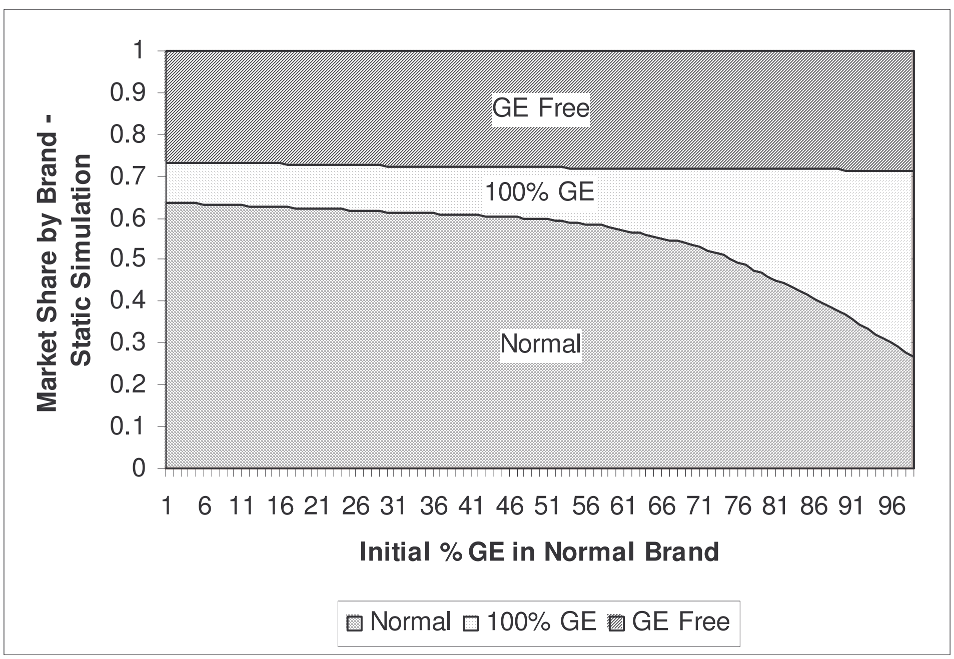


Figure 4. Static Simulation Results - Heterogeneous Population.



(a) No Warning Labels



(b) With Warning Labels

Figure 5. Static and Dynamic Share of GE Content Across All Brands for a Heterogeneous Population

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