The Informational and Signaling Impacts of Labels:
Experimental Evidence from India on GM Foods

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Abstract

Much of the debate between the European and U.S. positions about labeling of genetically modified foods has been whether consumers perceive labels as a source of information or a signal to change behavior. In this paper, we provide an experimental framework for examining these roles of information and signaling. While previous studies have focused on the impact of labels on consumer behavior, our interest is also what happens prior to the expression of aversion to GM-labeled foods. In particular, the experiment design allows the researcher to estimate a lower bound of the informational impact of labels on GM food aversion. The other novel feature of this paper is that unlike earlier studies, it uses subjects from a developing country.

Key words: Genetically modified foods; experimental methods; informational impact of labels; signaling impact of labels

JEL Codes: C9, Q13, Q16, Q18, L15

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1. Introduction

Policies towards labeling of genetically modified or GM foods have varied between countries. The great divide has been between the policies in the European Union (EU) that has favored mandatory labeling and the United States, which has chosen not to impose such requirements. Developing countries have also been confronted with this issue. While Brazil and China have adopted mandatory labeling laws, Philippines and South Africa have pursued approaches based on voluntary labeling. In India, a proposal for mandatory labeling of all GM foods is being actively considered by the government[1].

The EU has favored mandatory labeling of GM foods as a policy that responds to the consumer's right to know. The label simply identifies the food and does not carry any safety warnings.[2] It is believed that consumers have preferences over the process by which food is produced and such informed choice is promoted by mandatory labeling. The US position, on the other hand, is based on the principle of `substantial equivalence'. If a GM food demonstrates the same nutritional characteristics and composition as its conventional counterpart, then it is deemed to be just as safe and therefore not subject to mandatory labeling. Only those novel foods that are significantly different from their conventional counterparts are seen to be deserving of mandatory labeling. Such a product-based regulation assumes that consumers have preferences only over products and not processes.

In this perspective, a mandatory label for a substantially equivalent GM food may mislead a consumer into believing that the food is unsafe (Runge and Jackson, 2000) even when the label is simply a summary of whether or not the food was produced using GM technology. The US Health Secretary is quoted as saying "Mandatory labeling will only

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[1] India passed such a regulation for all the packaged products in May 2012.The regulation would be effective from January 1, 2013.
[2] For example, "This product is genetically modified" or "This product contains GM ingredients"

frighten consumers. Labeling implies that biotechnology products are unsafe" (Associated Press, 2002). Such an argument implies that labels, even when neutrally worded, are signals and therefore change consumer behavior. Lusk and Rozan (2008) find some support for such effects. From a survey of US households, they conclude that individuals who believe the government enforces a mandatory labeling policy are less likely to be willing to purchase and consume GM food than individuals who believe no such policy is in place. Thus, EU and U.S. positions differ on the mechanisms through which mandatory labeling is likely to affect the demand for GM foods. The EU posits an informational role for labels. Previously uninformed consumers see the label and adjust demands according to their preferences about GM foods. The argument made by U.S officials opposing mandatory labeling posits a signaling role for labels. Consumers read the label as a signal that the product may have unspecified health consequences and accordingly place demands. In this paper, we provide an experimental framework for examining these roles of information and signaling. In particular, the experiment design allows the researcher to estimate a lower bound of the informational impact of labels on GM food aversion. To the best of our knowledge, such an analysis has not been done earlier.

This paper is a contribution to the literature on consumer preferences and perceptions of GM foods. Like much of the literature, we too conduct experiments where subjects bid for foods with money. In a typical experiment study, valuations are elicited for a GM and a non-GM food. As it is not possible by visual inspection to ascertain whether a product is GM, the foods used in the study are appropriately labeled. Huffman, *et al.* (2003, 2004), Lusk *et al.* (2006) and Noussair *et al.* (2002, 2004), Dannenberg *et al.* (2010) are some of the studies that have utilized such experimental data to analyze consumer demand for GM food. European and US consumers are the subject of these studies.

Our paper is, however, a departure from the literature in an important way. It sets up a framework for consumer valuation that allows play to the contrasting views of labels implicit in the European and US positions. This leads to an experiment design that allows the researcher to estimate a lower bound to the informational impact of labels. While prior studies have investigated the effect of different kinds of labels and information on consumer valuation of GM foods, these findings have not been related to the dual pathways of information and signaling by which labels matter. The focus of the literature has been whether labels (and associated information) matter. To this end, papers typically report findings about the extent of aversion to GM foods i.e., the discount on GM foods relative to valuations on equivalent non-GM foods. This paper also reports the aversion to GM foods; in addition, however, it also shows the minimum (or maximum) proportion of this aversion that can be ascribed to the informational impact (or the signaling impact). In this sense, the paper advances the literature by widening the question of research from whether labels matter to how they matter.

In addition, we use subjects from New Delhi, India, outside the usual developed country context. Consumers in developed countries are widely exposed to the debates on GM foods but media attention to GM foods has been limited in India. The market dynamics in a developing country could be very different from that of a developed country and therefore, may require a different set of policies. We are not aware of prior studies that investigate consumer preferences towards GM foods in a developing country context using experimental methods.

The next section sets out a theoretical framework. The application of this framework to devise an experiment is described in section 3. This is followed by a review of literature.

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The experiment and the subject pool are described in Section 5. Findings are reported in sections 6 and 7.

2. The Informational and Signaling Impact of Labels

Consider a framework where GM and non-GM products are vertically differentiated (based on the unit demand model of Mussa and Rosen, 1978) and where consumers have a higher willingness to pay for the non-GM attribute.[3] An individual consumer buys at most one unit of the good, which could be GM with probability π, where $\pi \in [0,1]$.

For the purpose of exposition, consider first a model where a label serves to provide only information. We posit that either quality (GM or non-GM) provides the same basic utility, v, but consuming the GM variant also leads to a disutility that differs across consumers. The disutility is non-decreasing in the probability of the product being GM.[4] Specifically, utility is given by

$$U = v - g(\pi;\theta) \tag{1}$$

where g is a reduced-form representation of the cognitive processes by which consumers map probabilistic information to utility outcomes. It is a function of π, i.e., the consumer's perception of the probability that a product is GM, and θ . arameter θ in the disutility function varies across consumers. It allows consumers to differ in their aversion towards GM attribute even for products with the same probability of being GM.

The function g is non-decreasing in π for GM averse consumers.[5] Further assume, that at the supports,

$$g(0;\theta) = 0, \qquad g(1;\theta) = \theta\overline{G}, \qquad \text{where } \overline{G} > 0 \tag{2}$$

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[3] The Mussa-Rosen model is widely employed in the theoretical literature on the economics of GM food labeling (Fulton and Giannakas (2004), Kirchhoff and Zago (2001), Lapan and Moschini (2004, 2007)).

[4] A discrete version of the model where there are only two variants – GM and non-GM, is considered by Lapan and Moschini (2007).

[5] For GM loving consumers, the function g is non-increasing in π and $\overline{G} < 0$.

In other words, the maximum disutility (for a fixed θ) occurs at $\pi = 1$ and the least disutility occurs at $\pi = 0$. Thus effectively v is the utility derived from one unit of the non-GM variant, i.e., $v = U(non\ GM)$, and $\theta\overline{G} = U(non\ GM) - U(GM)$.

The utility function in (1) can be related to both, the expected utility, and the Prospect Theory formulations (Kahneman and Tversky, 1979). Prospect theory modifies standard expected utility theory by replacing objective probability weights with so called "decision weights". Thus, a Prospect theory utility would be given by

$$U^P = U(non\ GM) - w(\pi)\ (U(non\ GM) - U(GM))$$

$$= v - w(\pi)\theta\overline{G}$$

where $w(\pi)$ is the subjective weight assigned to the probability π. Notice that for $w(\pi) = \pi$, the above formulation collapses to the expected utility theory. Hence, expected utility theory and prospect theory imply particular forms of the disutility component of (1).

If consumers behave according to expected utility, their disutility from GM foods is linearly decreasing in π. In Prospect theory, the shape of the weight function $w(\pi)$ determines how disutility varies with π. Kahneman and Tversky point to a `certainty effect' that they deduce from their experiments. "Certainty effect is a phenomenon where people underweight outcomes that are merely probable in comparison with outcomes that are obtained with certainty." This would imply that $w(\pi)$ is larger at values of π close to 1 compared to low values of π. However, there are no predictions about this function for all values of π.

Suppose R_0 is the reservation level of utility that a consumer gets when the good is not purchased. Then the maximum that a consumer is willing to pay for a product that is genetically modified with probability π is W_π that satisfies

$$W_\pi = v - g(\pi;\theta) - R_0 \qquad\qquad (3)$$

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At the supports of π, the maximum willingness to pay becomes $W_0 = v - g(0, \theta) - R_0$ and

$W_1 = v - g(1, \theta) - R_0$. The difference is the measure of aversion to GM foods, namely

$$W_0 - W_1 = g(1, \theta) - g(0, \theta) = \theta \bar{G} \tag{4}$$

(4) is the aversion to GM foods that arises from the informational impact of labeling. To

incorporate the signaling impacts, we assume that the intrinsic utility v is sensitive to signals

or cues. In particular, at the supports of π, assume the utilities are

$$U_0 = v_0 - g(0; \theta) \tag{5}$$

and

$$U_1 = v_1 - g(1; \theta) \tag{6}$$

where $v_0 > v_1$. This captures the idea that labels are signals to consumers to shift down their

valuation of GM foods. Equations (5) and (6) imply that the aversion to GM foods can be

written as

$$W_0 - W_1 = (v_0 - v_1) + (g(1, \theta) - g(0, \theta)) \tag{7}$$

(7) says that the aversion to GM foods now comprises two terms: a signaling impact of a

label (the first term) and an informational impact of a label (the second term).

3. Estimating the Informational Impact: The Idea of the Experiment

Measuring aversion to GM foods requires two data points: consumer valuations for a

non-GM food and consumer valuations for a GM food that is otherwise identical. The idea of

our experiment is to insert an intermediate stage and obtain three data points. The

intermediate stage consists of valuations for a food that is perceived as genetically modified

with some probability (in the interior of the unit interval).

The experiment in this paper (described in detail in a later section) consists of three

rounds of bidding for two products (cookies). In the first round, price bids are elicited on the

basis of blind tasting. In the second round, subjects are invited to read a one pager describing

GM foods and their status in regulation. Subjects are also asked to speculate on the probability that the products are genetically modified. Thus after planting some doubt that either one or both products might be transgenic, subjects are asked to make price bids. The third round price bids happen when one of the products is labeled and, thus revealed to be, as genetically modified.

The first round serves to normalize the subjective quality difference between the two products. The difference in third round price bids between the unlabeled non-GM product and the labeled GM product (normalized by the first round quality difference) is the expressed aversion to GM foods. The difference between the price bids of the two products in the second round (normalized once again) is the aversion to GM foods that comes from the diffuse and generalized information distributed in the second round. This information is crystallized in terms of subjective probabilities that one or both products are genetically modified. The extent of aversion in the second round relative to the third round is the lower bound to the informational impact of labels on GM aversion.

To see this clearly, let w_{ij} denote the willingness to pay for product j $(j = A,B)$ in round i $(i=1,2,3)$. Following (3), the valuations for the products A and B in round 1 are given by

$$w_{1A} = v_{NA} - g(\pi_{1A}; \theta) - R_0 \tag{8}$$

$$w_{1B} = v_{NB} - g(\pi_{1B}; \theta) - R_0 \tag{9}$$

where v_{Nj} is the intrinsic valuation of the product j $(j=A,B)$ in the absence of labeling. The difference in the first round valuations between the two products is therefore

$$w_{1A} - w_{1B} = v_{NA} - v_{NB} \tag{10}$$

where we have assumed that in the blind tasting round, the probability perceptions are equal across the two products. The difference in valuations stems entirely from difference in

intrinsic utility which presumably depends on taste, shape, appearance and other characteristics relevant to consumers.

Similarly, the willingness to pay in round 2 is given by

$$w_{2A} = v_{NA} - g(\pi_{2A}; \theta) - R_0 \qquad (11)$$

$$w_{2B} = v_{NB} - g(\pi_{2B}; \theta) - R_0 \qquad (12)$$

where π_{2j} is the probability perception that product j ($j = A, B$) is genetically modified. Recall that in round 2, subjects read an information sheet about GM foods and were asked to report their probability perceptions. The material basis for these perceptions is irrelevant to the experiment; as long as consumers form these probabilities, it will matter to their product valuations.

The difference in the willingness to pay between these two products in the second round becomes

$$w_{2A} - w_{2B} = (v_{NA} - v_{NB}) + g(\pi_{2B}, \theta) - g(\pi_{2A}, \theta) \qquad (13)$$

In the third round, product B is revealed to be genetically modified. Hence the probabilities of the two products would change accordingly. The label also modifies the intrinsic utility of the two products because of the signaling effect. Taking both these effects into account, the product valuations become

$$w_{3A} = v_{LA} - g(0; \theta) - R_0 \qquad (14)$$

$$w_{3B} = v_{LB} - g(1; \theta) - R_0 \qquad (15)$$

where v_{Lj} is the intrinsic valuation of the product j ($j=A,B$) in the presence of labeling. Hence the difference between the valuations of the two products becomes

$$w_{3A} - w_{3B} = (v_{LA} - v_{LB}) + g(1, \theta) - g(0, \theta) \qquad (16)$$

(16) is the premium of the non-GM food over the GM labeled food. To compute the aversion to GM foods, (16) needs to be adjusted for the intrinsic difference in qualities (such as taste,

color and appearance) between the two products as revealed in the first round. Subtracting (10) from (16) gives us the magnitude of aversion to GM foods, denoted as M, i.e.,

$$M = [(v_{LA} - v_{NA}) - (v_{LB} - v_{NB})] + [g(1, \theta) - g(0, \theta)] \qquad (17)$$

The effect of labeling on valuations can thus be computed by a routine difference-in-difference analysis between round three price bids and blind tasting price bids in round one – i.e., $M \equiv (w_{3A} - w_{3B}) - (w_{1A} - w_{1B})$. M is the quantitative measure of aversion to GM foods and it represents the premium of non-GM food over the GM product, controlling for all differences in intrinsic quality (in the unlabeled state). A subject is defined to be GM averse if $M > 0$. A subject is GM indifferent if $M = 0$ and is GM loving if $M < 0$.

In (17), the first term on the right hand side is the aversion to GM foods due to the signaling effect. The label alters the intrinsic utility and this is captured by the first term in (17). The label also certifies to the consumer which of the products is genetically modified and this information alters valuations as well. This is captured by the second term in (17). For the sample of GM averse consumers (N), the average aversion to GM foods can be computed as

$$\frac{\sum_{\theta} M}{N}$$

Similarly, the sample average of the informational component of (17) is

$$\frac{\sum_{\theta} [g(1, \theta) - g(0, \theta)]}{N}$$

From (10) and (13), it can be seen that what can at best be estimated is

$$V \equiv (w_{2A} - w_{2B}) - (w_{1A} - w_{1B}) = g(\pi_{2B}, \theta) - g(\pi_{2A}, \theta) \qquad (18)$$

(18) can be positive or negative depending on the relative values of π_{2A} and π_{2B}. However, as the disutility $g(.)$ is increasing in π, $| g(\pi_{2B}, \theta) - g(\pi_{2A}, \theta)| \leq g(1, \theta) - g(0, \theta)$. Hence

$$\frac{\sum_{\theta} |g(\pi_{2B}, \theta) - g(\pi_{2A}, \theta)|}{N} = \frac{\sum_{\theta} |V|}{N} \leq \frac{\sum_{\theta} [g(1, \theta) - g(0, \theta)]}{N}$$

Thus a lower bound to the sample average of the informational component of the aversion to GM foods is

$$\frac{\Sigma_\theta |V|}{N} = \Sigma \, |[\, (w_{2A} - w_{2B}) - (w_{1A} - w_{1B})\,]|/N \qquad (19)$$

Finally, the ratio

$$\frac{\Sigma_\theta |V|}{N} \, / \, \frac{\Sigma_\theta M}{N}$$

is the minimum proportion of aversion to GM foods that is due to information.

4. Survey of Literature

There is now a growing literature that uses experimental methods to assess the demand for GM foods. Some of the principal studies and their results are summarized in Table 1. The principal issue has been to measure the extent of aversion to GM foods as revealed by the auctions of GM and non-GM foods. In addition, a range of subsidiary questions have been explored such as the effect of different kinds of information about GM foods in general and about the GM product that is auctioned (e.g., the percentage of GM ingredients).

The cognitive process that is triggered by labels has not, however, received attention in experimental studies of consumer valuation of GM foods. Some of the studies, however, reveal some anomalies that point to the necessity of a deeper investigation of the cognitive processes.

Huffman *et al.* (2003, 2004) analyze the effects of labels when combined with different kinds of information (pro-biotech, pro-environment and so on). Subjects bid for the GM-labeled product in one round and a `plain' labeled product in another round. The plain label identified only the contents of the food package while the GM label also stated that the product was made using genetic modification. One set of participants were randomly

assigned to first bid for the foods with plain labels and then for the foods with GM label in the subsequent round. For other participants, the sequence was reversed. The significant finding is that the discount on GM-labeled foods is less when consumers first bid on GM-labeled foods compared to the reverse sequence. Clearly, this result may have something to do with how consumers process information from labels. Using experimental auctions in Germany, Dannenberg *et al.* (2011) investigate the impact of different labeling schemes on the ability of consumers to express their preferences. The authors show that consumer preferences are context dependent and find that the quality of the signal generated by a mandatory labeling scheme is affected by the number of labels in the market. Consumers value the un-labeled product differently when a GM-free labeled product enters the market under a mandatory labeling scheme.

Noussair *et.*al (2004) conduct an experiment where they auction four types of biscuits referred as S, L, C and N during the sessions. The first round consists of blind tasting followed by auctions. In the second round, the experimenters reveal the product type for S (`S contains GMOs') and N (`N is GMO free'). This is followed by an auction as well. No announcement is made for *L* and *C*. Yet, they report (Table 2 in the paper) a small decrease in average bids for these two products from round one to round two. In round three, labels for *L* (`No ingredient in *L* contains more than 1% GMOs') and *C* (`No ingredient in *C* contains more than 0.1% GMOs') are revealed. The auctions in this round lead to a sharp fall in the average bid for *L* and a modest rise in the average bid for *C*. The decline in average bids in round two could have happened because it is probable that the labels for *S* and *N* change the subject's perceptions of *L* and *C* as well. Therefore, this experiment is also suggestive that consumers may process probabilistic information in different ways.

Cognitive processes have been acknowledged in the literature on consumer research and marketing. Referring to this literature, Cryer and Ross Jr. (1997) state that "…recent

research suggests that many consumers do not have well-articulated preferences; consequently their choices and preferences are often influenced by the information available in the environment………. Different information formats seem to facilitate the use of different strategies and heuristics, which in turn may lead to differences in expressed preference and choice…. That preferences are often constructed during the choice process, rather than simply retrieved from memory, suggests that the information available at the time of choice has a significant impact on the decision outcome."

It is well known to survey researchers that consumer response is affected materially by how questions are posed and how information is presented. There is little reason to believe that labels are exempt from such framing effects. For instance, Grankvist, Dahlstrand and Biel (2004) compare "positive" and "negative" eco-labels. Positive labels advertise the environmental benefit of the product while negative labels indicate the adverse outcomes to the environment. Their experiment shows that the label type did not matter either to consumers with no interest in environmental affairs or to those with strong interest in environmental protection. However, preferences of individuals with an intermediate interest in environment were more affected by a negative than a positive label. In another application of eco-labeling, Tiesl, Rubin and Noblet (2008) model the process by which preferences are formed. They show that the impact of labels depends on a number of other factors including prior perceptions, cognitive abilities, the credibility of information and personal characteristics.

The economics literature is now beginning to acknowledge the cognitive process by which consumers absorb information. For instance, it has been suggested that people have a limited capacity to process signals and only signals that are sufficiently intense are perceived. Consumers dedicate their attention capacity to the 'strongest' signals, i.e., the signal must be strong enough to have an impact (Falkinger 2008). Kooreman (2000) analyzed the effects of

the Dutch child benefit system on household expenditures and found that child benefits increases the expenditures on child goods more than other income sources. He proposes that parents regard the child benefits as a normative benchmark and therefore government policy changes parents' preferences towards children's goods. He reports this *as the labeling effect of a child benefit system.*

We would interpret Kooreman's explanation as a signaling effect of a label. As mentioned in the introduction, U.S. government officials have opposed mandatory labeling of GM foods because they fear a signaling impact of the label as a result of which consumer preferences turn away from GM foods.

5. Subject Pool and Experiment Design

The experiment is designed to measure changes in willingness to pay in response to new information about GMO content. The protocol we use is similar in spirit to several other experimental protocols in the literature that use Vickrey (1961) auction type techniques like Noussair *et al.* (2002, 2004) and Lusk et al. (2004, 2006). In fact our experiment is modeled on the Noussair *et al.* (2004) design to elicit WTP using the Becker-DeGroot-Marschak mechanism (BDM, Becker et al., 1964).

We ran three separate experimental sessions. Two of the sessions used Bachelors degree students in Engineering (from the Indian Institute of Technology (IIT) in New Delhi). The other session consisted of university teachers from all parts of India (participants at a training course at the Jawaharlal Nehru University (JNU) also in New Delhi). These sessions were preceded by a pilot with another group of students where the experiment protocol was tested. Data from this pilot is not used in the study.

Of the total pool of 114 subjects, 64 were students and the 50 were older university teachers. As a result, about 58% of the subject pool is less than the age of 25. Most of the

college teachers are in the early stages of their career – only about 9% of the subject pool is 36 or greater. About 39% of the subject pool is female. In terms of parental background, most of the subjects come from families with high levels of educational attainment. Nearly 76% of the subjects have fathers who have studied beyond high school. The corresponding figure for mother's education is 52%. About 69% of the subjects report family incomes in the range of Rupees 100,000 to Rupees 500,000 which spans the range of what is known as the middle class in India. These incomes are well above median incomes in India.

Our study sample represents urban consumers with higher than average family incomes and educational attainment. This group is worthy of study because (a) their attitudes and lifestyles are aspired to by other socio-economic groups and more importantly (b) they are the primary consumers of packaged foods that would be subject to mandatory labeling laws.

The experiments were conducted in large classrooms with the subjects seated away from each other. They were trained in the bidding protocol using a quiz and were not allowed to communicate during the session. In our BDM auctions the subjects had an endowment of 200 units of lab currency (deemed Francs, which convert to Indian Rupees at the rate of 4 Francs to a Rupee). In each round of the four rounds of auctions, they gave in writing the price that they would be willing to pay for a unit of both the products (the GM and the non-GM). After all the four rounds were complete, one round was randomly picked and a valuation for each of the two products was picked from the uniform distribution [1, 100]. If a participant's valuation was above this, he or she would purchase a unit at the drawn price, otherwise he or she would keep her endowment to take home in Rupees.

In the BDM auction, bidders have a dominant strategy in bidding an amount equal to their true valuations for the good. In principle this allows willingness to pay (WTP) be directly measured, rather than inferred. For a discussion regarding the use of the BDM

mechanism see Noussair et al. (2004). Further though we deem it an "auction" there is no strategic (in the standard game theoretic sense) incentive as in a usual sealed bid auction as every participant whose valuation lies above the drawn price wins a unit. Also note that when bidding for the products, we do not make the bids public information at any time, so that privacy of the valuations is safeguarded and subjects cannot use others' bids to update their own valuations. The time line for the procedures is given in Table 2. Note that this sequence of auctions is modeled on Noussair et al. (2004) with one difference. In our protocol, probabilistic information is given (in the form of general "balanced" information regarding GM products) before any product specific information (in our case a GM label) is provided to the subjects.[6] Whereas Noussair et al. (2004) go on from their blind tasting auction directly to providing information regarding the products being auctioned, we give them a handout that provides information on GM products and conduct a BDM auction before we provide product label information. This allows us to tease out the informational impact of labels from its signaling effect.

We auction two products, which we called *A* and *B* during the session. The products were chocolate chips cookies that are available in stores in Delhi. The products were close substitutes; very similar in taste and appearance. The experiment consisted of four rounds of bidding, as outlined in Table 2. Once subjects arrived they were asked to complete a survey that elicited basic demographic information and had questions about their attitudes towards (so called) healthy habits. After completing the survey the experiment began. At the beginning of the experiment, subjects received a sample of both products without its packaging or labeling. Before bidding in the first period, subjects were required to taste each product. Then they marked down how much they liked the product on a scale where "I like it very much" and "I don't like it at all" were at the extremes of the rating scale. Then the first

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[6] The background information describes GM foods, examples of genetically modified plants, the status of their regulation in India, the reasons for opposition by some groups and their food safety assessment by the WHO.

period auction took place. The two products were auctioned simultaneously. Each of the following periods consisted of the revelation of some information (general or product specific), followed by a simultaneous auction for both products. The sale price was not drawn for any period until the end of period four and no information was given to participants about other players' bids.

At the beginning of the second period, we distributed a handout containing information about GMOs. The information was an unbiased characterization so as not to affect consumer preferences towards GMO. The information handout is given in Appendix.

At the beginning of the third period, we revealed the information regarding the GM status of the product. The products were still enclosed in our packaging (and not the manufacturer's packaging) and they had labels designed by us. On both products, the label read "Chocolate Chip Cookies". But the label of product B had an additional statement which read "This product may have been subject to genetic modification". The label matched the proposed stipulation regarding GM labeling in India. Thus we revealed it to the participants that product A is GM-free and product B could be subject to genetic modification. Finally in the last period, we revealed the brands of two products in the original packaging. The price bids received in this round play no role in our analysis. We included this round in the experiment to assure the subjects that the products were genuine.

6. Taste Rankings, Information and Subjective Probabilities

In the blind tasting, subjects are asked to rank each of the products on a taste scale of one to seven (higher is the number, greater is the liking) with increments of 0.5. Therefore, a choice is made from 14 possible values. Figure 1 plots the empirical cumulative density function of rankings for both these products. If one ignores, the crossing of the distributions at low taste levels, rankings for product A (which in later periods is revealed to be the non-

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GM product) dominate that of product B (revealed later to be the GM product) by first order stochastic dominance. The sample mean of the taste rankings of product A is 4.96 and that of product B is 4.44. The Spearman's rank correlation between the two taste rankings is –0.1664 and the null that the rankings are independent is not rejected at the 8% level of significance.

In period two, subjects were asked to evaluate the likelihood of either product being GM on a scale of 1 to 5. Figure 2 plots the empirical cumulative density of this evaluation. As can be seen, the proportion of consumers who regard product A (the non-GM product) as GM is higher than the similar proportion for product B at all likelihood levels from one to five. Thus, the sample mean of the likelihood that product B is GM is higher than that of product A (2.96 for B as against 2.63 for A). For ease of interpretation, these perceptions are transformed from the likelihood scale of 1 to 5 to probabilities in the unit interval [0,1].

For most of the subjects, the probabilities are strictly in the interior. Only a total of nine subjects report unit probabilities for either of the products.[7] In addition, only 20 subjects report prior probabilities of less than or equal to 0.25 on both products. Therefore, for the bulk of the subjects, the probabilistic perception about the products is in mid-range.

The sample means for both products indicate that the average probability that either product is GM is close to 0.5. Out of the 113 subjects who report both these subjective probabilities, 88 of them have a probability of at least 0.5 on either or both products. Thus, the background information on GM foods provided in period 2 leads subjects to form high subjective probabilities for at least one of the products. With such high subjective probabilities, it is expected that it will affect the price bids of those who are GM averse. In particular, if the sample is characterized by aversion to GM foods, then higher subjective

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[7] No one reports unit subjective probabilities for both products.

probability should lead to lower price bids. Notice that the discount in food values has to be attributed entirely to information.

Table 3 reports the regression results. In column 1, the second period bid price of product i (i =A, B) is regressed against its first period bid price, the first period bid price of the other product, the subjective probability that product i is GM, the subjective probability that the other product is GM, product i's taste ranking revealed from the blind tasting round and the taste ranking of the other product.

As might be expected, the second period bids are highly (and positively) correlated with first period bids of the same product. Furthermore, the GM probability perception of a product drives its valuation down. The first column results suggest that other things held constant, an individual with a probability perception of 0.5 has a valuation lower by Rs. 8 than an individual with a probability perception close to zero. Once again, it has to be stressed, that the lower valuation of the GM food here is to be entirely attributed to information.

Columns 2 and 3 check the robustness of this result to the inclusion of variables relating to personal characteristics. In column 2, the second period bid price of product i (i=A,B) is regressed against the variables related to demographics (age, income) and attitudes towards healthy habits (frequency of exercising and snacking) in addition to the variables in column 1. Column 3 adds a gender dummy to the regression. Although many of these variables affect the dependent variable in the expected direction, none of them are significant. The second period valuations continue to be significantly and negatively impacted by the perception that the product is GM.

But do probability perceptions matter to everybody in the sample? Out of the 114 subjects, 101 report price bids in both periods. And out of these 101 subjects, 36 (i.e., more than a third) did not alter their price bids (for both products) from period one to period two.

We call these as "information inert" subjects because their price bids are invariant to the elicitation of subjective probabilities and to the background information on GM foods that was distributed in the second period. Therefore the negative relation between second period bids and the subjective probability in the regression of Table 3 comes from rest of the sample.

Individuals could be information inert because of two reasons. The first possibility is that the information does not change bids because the subjective probabilities remain low. The second possibility is that the disutility component of the utility function in (1) is flat in the relevant range of probabilities. Table 4 reports the averages of the subjective probabilities of information inert and non-information inert subjects. These figures show that the subjective probabilities of the inert subjects are indeed lower than that of non-inert subjects. However, in no case is the difference statistically significant at the 5% level. Therefore, the first reason is unlikely to be the reason for information inertness. Rather it seems that the disutility component (the g function) is invariant to the subjective probability. Thus, while in the aggregate, probabilistic perceptions of foods being GM do negatively affect their valuation, this is not true for a fraction of the sample that is information inert.

7. The Informational Component of Aversion to GM foods

As explained in section 3, the difference in valuation because of the GM label is $M \equiv (w_{3A} - w_{3B}) - (w_{1A} - w_{1B})$. This is the quantitative measure of GM aversion and it represents the premium of non-GM food over the GM product. Recall a subject is defined to be GM averse if $M > 0$. A subject is GM indifferent if $M = 0$ and is GM loving if $M < 0$. Table 5 classifies the sample according to these definitions.[8] About half of the sample is GM averse and the remainder are equally split between GM loving and GM indifferent subjects.

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[8] The table classifies 101 subjects who report bids for both products in periods one and three. The remainder thirteen subjects do not report bids for both products and in both periods   .

Sample averages of *M* and *V* (the lower bound to the informational component of *M* as defined in (19)) together with their standard errors are presented in Table 6. The first column presents the results for the entire sample. Here the measure of GM aversion is Rupees 7.44 which is a premium of about 16% on the average bid for the GM product in round three (Rupees 48). This compares to the 25% premium that Lusk (2011) found to be the average across 57 studies of consumers in the US, Europe, China, Japan and Taiwan. European consumers typically report even higher willingness to pay premiums for non-GM food.

However, the modest aversion on average, in this study, conceals the wide variation among consumers as GM aversion is confined to only about half of the sample. As a result, the average aversion among the GM averse (in column 2) is much higher at Rs. 24 which represents a premium of 50% over the average bid for the GM product in round three. As our sample was representative of urban, well-educated middle-class subjects, it is likely that aversion would be lower in a more representative sample of the economy.

Table 6 also shows among the GM averse, 60% of aversion is due to the probabilistic information in round two. As was argued earlier, this represents a lower bound to the informational component of GM food aversion. It can therefore be concluded that the informational role of labels dominates that of the signaling impact in these experiments.

There are important differences, however, within the group of GM averse as well. The earlier section noted the presence of `information-inert' consumers whose valuations do not respond to probabilistic information. The last two sets of columns of Table 6 present the magnitudes of GM aversion for (a) the subset of GM averse consumers who are not information inert and (b) the subset of GM averse consumers who are information-inert. As can be seen, the sub-samples reveal similar aversion to GM foods. However, these two groups are very different with respect to the informational component *V*. For those who are GM averse and not information inert, the lower bound is as high as 76%. Information is

therefore the dominant driver of GM aversion for such subjects. On the other hand, for those who are information inert, the aversion to GM foods is revealed only in round three when the foods are labeled. As it is impossible to say how much of this is because of the signaling or the information content of the label, this experiment cannot usefully estimate the informational impact for this group of consumers.[9] It is probable that the signaling impact is strong for the information-inert consumers but this cannot be deduced from this experiment.

8. Conclusions

This paper aims at studying consumer attitudes towards GM foods in the context of a developing country, India. The data set is obtained by assigning labeling and information treatments to subjects who participated in lab experiments of food items that might be genetically modified. Previous studies of consumer preferences towards GM foods have focused on the impact of labels on consumer behavior. On that basis, they have concluded about the extent of aversion to GM foods. In this paper, our interest is also what happens prior to the expression of aversion to GM-labeled foods. In particular, the paper investigated the effect of probabilistic information on GM food aversion using experimental methods. On the basis of existing research in consumer psychology and marketing, the paper postulated that different consumers may process probabilistic information differently. The experiment is designed to estimate a lower bound to the informational impact of labels on GM aversion.

We obtain a number of interesting results. First, we find that, on average, consumers are willing to pay a price premium of about 16% for GM free products. However, GM averse consumers account only for about 50% of the subjects. Our results are in sharp contrast to that obtained by Noussair et al. (2004), where participants in the experiment were French consumers. Whereas only 23% of participants in their study showed no decrease in their

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[9] The lower bound to the informational impact of the label is zero.

willingness to pay after learning that a product contained GMOs, the corresponding number is 50% in our study. More strikingly, 35% of French subjects were unwilling to purchase products made with GMOs, while in our sample there are only 8% of such subjects. These results suggest that preferences in a developing country could be different from those in a developed country leading to a different market dynamics.

Second, for the sample of GM averse consumers, the informational impact of labels dominates the signaling impact. Third, a subset of GM averse consumers did not react to the probabilistic information at all. It is the revelation of a label that leads them to place a premium for non-GM products. It is possible that the signaling impact is important for these consumers. To demonstrate this, it would be necessary to design an experiment where subjects are shown cues that have no information content but could be interpreted as signals from credible authorities.

Role of the Funding Source

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Appendix I

Background information about GMOs

1. What are genetically modified foods?

Foods derived from plants that are genetically modified are called genetically modified (GM) foods. A plant is genetically modified if it contains genes that have been inserted using genetic engineering techniques.

2. How is genetic engineering different from traditional plant breeding?

Genetic engineering makes it possible to insert a gene from another organism (such as another plant species, bacteria or animal) into the plant variety of interest. This is not possible with the traditional techniques of producing improved plant varieties.

3. Why are GM foods produced?

GM foods are developed – and marketed – because there is some perceived advantage either to the producer or consumer of these foods. The first generation of GM plants have given more direct benefits to growers than to consumers although the latter have possibly gained from lower prices.

4. What are examples of genetically modified plants?

The principal examples of genetically modified crops occur in soyabeans, maize (i.e., corn) and cotton. For instance, genes from a commonly found soil bacteria have been used to produce soybeans, maize and cotton that are naturally resistant to certain pests.

5. Why are GM foods regulated?

There are two broad concerns with GM plants. First, because the foods are novel, the must be tested for toxicity and possible allergenicity. The second issue is whether the engineered gene can escape into wild populations and other unintended plants. For these reasons, GM crops must be assessed for food and environmental safety before they can be planted.

6. What is the status of GM foods in India?

In India, no GM food crop has been approved for planting yet. Therefore, foods produced from domestically produced crops are not genetically modified. Foods that are imported could contain ingredients that are genetically modified. As of now, India does not have separate regulations for imports of GM food other than what applies to imported foods generally.

7. Why do some people oppose GM foods?

Several NGOs and individuals claim that GM plants pose unacceptable risks to food safety as well as environment safety. They argue that transferring genes between organisms creates new risks for human health that cannot be fully comprehended by our existing scientific knowledge. They would therefore recommend that GM foods should be banned or severely

curtailed until risk assessments are more comprehensive in testing the adverse effects on human health.

This is disputed by biotechnology advocates who point out that GM crops are extensively tested before they are approved. According to the World Health Organization (WHO), "GM foods currently available on the international market have passed risk assessments and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved."

Table 1: Other studies that experimentally study the valuation of GM foods

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Noussair et al. (2002)	Used a demographically representative sample of consumers in Grenoble France. Their Vickrey auction illustrated that subjects rarely looked at labels (containing information on GM content), but when they did (operationalized in the experiment by displaying the label using an overhead projector) the WTP for the GM product declined by almost 30 percent with respect to the non-GM product.
Noussair et al. (2004)	Used the BDM (Becker-DeGroot-Marschak) mechanism in order to elicit WTP for four products which were graded from one which did not contain any GM ingredient with certainty to one where it is known with certainty that there is a GM ingredient. The two other products had a (small) probability of containing GM ingredients. Average bids indicated that the WTP for the GM free product was on average between 40 and 50 per cent higher than the product with GM ingredients. For the products with "not more than" 1 per cent (0.1 per cent) GMO respectively, the average WTP rose (fell) as more information became available to subjects over rounds of the auction.
Huffman et al. (2003)	Used the random nth price auction on adult consumers in the USA. On average consumers bid significantly less for the GM product for all three goods they consider. About 26% of the subjects bid less for all three GM-labeled products than for standard-labeled products and overall consumers' WTP was 14 per cent higher for the non-GM goods.
Huffman et al. (2004)	Identical allocation format (nth price auction) and subject pool to Huffman et al. (2003). They consider the effect of different information conveyed by special interest groups (environmental groups, biotech companies and a balanced third party perspective). They find that while the biotech company and the balanced perspective lead to subjects being less likely to display WTPs for the GM products that are significantly less than the non-GM product, the environmental group perspective does lead to subjects displaying a WTP that is significantly lower for the GM product vis-à-vis the non-GM product.
Bernard et al. (2006)	Employed a Vickrey auction on US college students, giving neutral information about the products being auctioned. The products were tortilla chips, milk chocolate and potato chips. In all product categories auctioned subject WTPs are significantly higher for the organic (non-GM) alternative.
Lusk et al. (2004)	Employed a fifth price Vickrey type (WTA) auction on female consumers (25-65) in the USA and EU. Subjects bid amounts that they are willing to accept to exchange their non-GM cookie for a GM-cookie. Overall Information regarding environmental benefits, health benefits and "world" benefits provided by GM cultivation significantly decreased the WTA bids for the GM cookie in all locations except France.
Lusk et al. (2006)	Methodology and experimental design same as Lusk et al. (2004). The median compensation demanded by English and French consumers to consume the GM cookie is found to be more than

	twice that in any of the US locations.
Liu (2009)	Replicated Lusk et al. (2004) in terms of design and protocol but differed in that different cohorts of subjects (Chinese undergraduate students) were given positive and negative information regarding GM food. Positive information decreased the WTA while negative information increased the WTA amounts.
Dannenberg et. al. (2011)	Used a Vickrey second price auction similar to Noussair et al. (2002) and showed that the quality of the signal generated by a mandatory labelling scheme is affected by the number of labels in the market. In their experiment, with two labels (one for GM and one for non-GM) mandatory and voluntary labelling schemes generated a similar degree of uncertainty about the quality of products that did not carry a label.

Table 2

*Sequence of Events in the Experiment Session*

Period 1	- Information: blind tasting of two products
	- Recording of hedonic rating of the two products
	- Auction
Period 2	- Additional information: General information about GM products
	- Recording of consumer perception about likelihood of each product being GM
	- Auction
Period 3	- Additional information: Product A is non-GM and product B may be subject to genetic modification (Product Labeling)
	- Auction
Period 4	- Additional information: Brand names of the two products
	- Auction
Transactions	- Random draw of the auction that counts towards final allocations
	- Random draw of sale price of two products
	- Implementation of the transaction for the period that counts

Figure 1: Cumulative density function of taste rankings
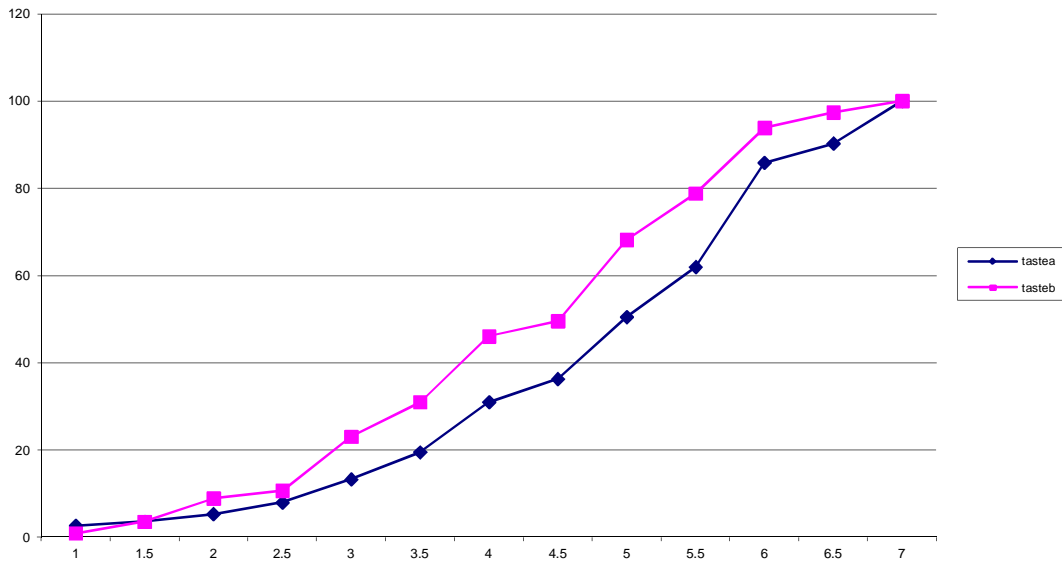
tastea is the sample cumulative density function of the taste rankings of product A (the non-GM cookie) while tasteb is the sample cumulative density function of the taste rankings of product B.

Figure 2: Cumulative density function of GM likelihood rankings
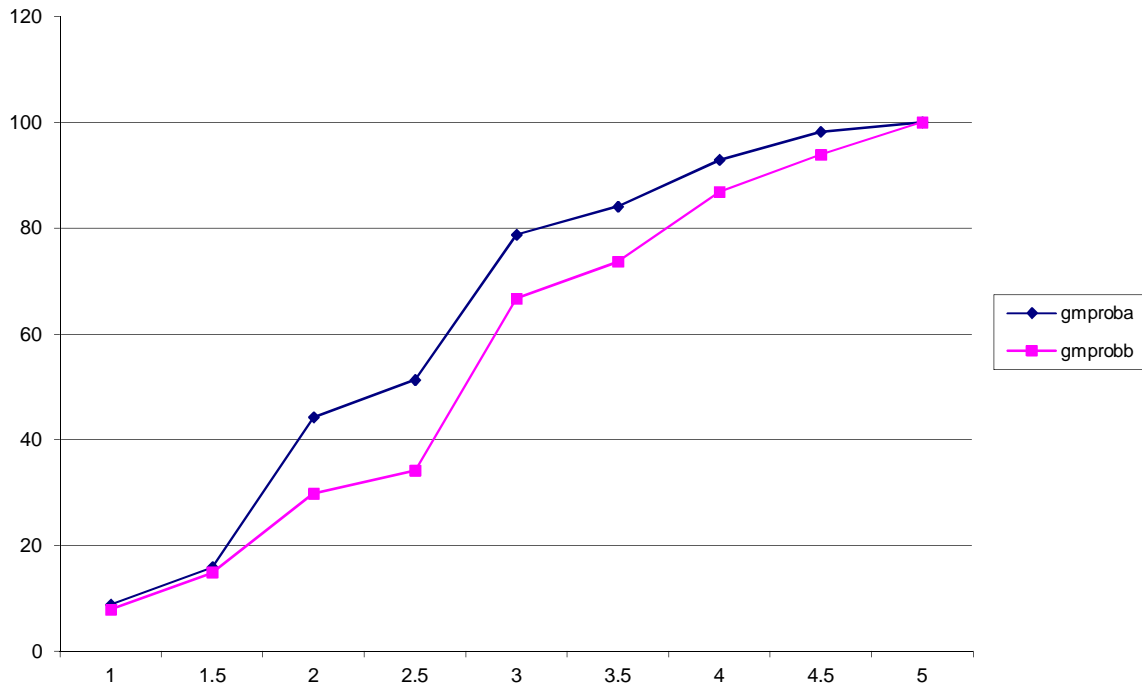
gmproba is the sample cumulative density function of the respondent's assessment of the likelihood that product A is genetically modified. gmprobb is the sample density function of the respondent's assessment of the likelihood that product B is genetically modified.

Table 3: The determinants of second round bids

Variables	(1)	(2)	(3)
First round price bid	0.847***(0.06)	0.851*** (0.06)	0.850*** (0.06)
First round price bid for other product	0.05 (0.05)	0.05 (0.05)	0.05 (0.05)
Probability that product is GM	-15.80*** (5.46)	-15.52*** (5.44)	-14.84*** (5.42)
Probability that other product is GM	3.80 (5.36)	4.08 (5.22)	4.77 (5.25)
Taste Ranking of product	-0.85 (1.01)	-1.09 (1.06)	-1.02 (1.06)
Taste Ranking of other product	-2.515** (1.06)	-2.763** (1.07)	-2.692** (1.07)
Youth		3.48 (2.31)	2.21 (2.25)
Male			3.32 (2.48)
Exercise		-3.69 (2.96)	-3.66 (2.95)
Snack		-0.25 (2.60)	-0.32 (2.59)
Income		1.60 (3.82)	2.37 (3.89)
Constant	28.51*** (9.05)	29.04*** (9.39)	26.22*** (9.48)
Observations	202.00	202.00	202.00
R-squared	0.65	0.66	0.66

Notes to Table 3: The figures below the coefficients denote robust standard errors. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. The variables youth, male, exercise, snack, and income are binary variables that take value 1 when the subject is 25 years or less in age, is a male, exercises more than twice a week, snacks processed foods more than twice a week, and has annual family income in excess of Rs. 500,000 respectively.

Table 4: Difference in Average Subjective Probabilities between Inert and Non-Inert Subjects

	Inert Subjects	Non-Inert Subjets	Difference	p-value of test that difference = 0
Probability that A is GM	0.375	0.415	0.04	0.45
Probability that B is GM	0.416	0.498	0.08	0.17

Table 5: Classification of Sample

	# Subjects	% of sample
GM Averse	51	50%
GM indifferent	25	25%
GM loving	25	25%
Total	101	

Table 6: Aversion to GM product and its Informational Component: Sample Means

	All sample	Sample of GM averse	Sample of GM averse and not information-inert	Sample of GM averse and information-inert
M: Premium of non-GM product to GM product	7.44 (2.62)	23.76 (3.43)	24.07 (4.04)	22.63 (6.4)
V: Lower Bound to the informational component of *M*	-----	14.27 (3.42)	18.2 (4.16)	0
Proportion of *M* due to *V*	-----	60%	76%	0%
Observations	101	51	40	11

Note: The figures in parenthesis denote standard error.