An Econometric Evaluation of Producers' Preferences for Mandatory Labeling of Genetically Modified Food Products

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This study uses multivariate statistical procedures to assess producers' preferences for mandatory labeling of genetically modified (GM) products. The analysis is based on a sample of 1,887 farm producers in ten Southern states of the U.S. who claimed to be "somewhat knowledgeable" about biotechnology. A logistic regression model was employed to isolate characteristics of producers assumed to influence their perceptions of biotechnology and preferences for mandatory labeling. The study highlights a number of important findings with significant implications. It reveals that most producers in the ten states are older (average age is 58 years) and have some college education but remain part-time farmers, dependent largely on off-farm income for their livelihood. The majority raise beef cattle or produce hay and timber. Most producers are in favor of mandatory labeling even though only half of the respondents totally agree with it. They believe biotech will benefit larger farmers, and that farmers will be dependent on large corporations that develop and market biotechnology inputs. The majority are neutral about whether consumers will accept biotech crop products. They also remain undecided about government's ability to properly regulate agricultural biotechnology. Limitations and benefits of biotechnology, education, and enterprise characteristics significantly influence producers' probability of being in favor of mandatory labeling. Information sources such newspaper, radio, and television; race; age; and whether a county was underserved do not significantly affect producers' perceptions regarding mandatory labeling of GM food products.

The objective of the Nutritional Labeling Education Act was to provide consumers with nutritional information to help them make informed choices that would assist in maintaining healthy dietary practices. As science evolves, more agricultural producers are using genetically engineered ingredients in their products. For consumers, the question becomes one of whether or not agricultural producers should label genetically modified (GM) food products as such. The question for producers is whether consumers will continue to purchase a product once the GM-label is implemented?

Hoban (2001) reports that "nearly 92 percent of food industry leaders believe that mandatory biotechnology food labeling—which proponents often position simply as an informational tool—would instead be perceived as a "warning" by at least some consumers." Will there be any repercussion for producers implementing a mandatory GM-labeling program? Furthermore, will implementing such a program merely for the consumers' right to know assist or cause greater confusion? As an alternative to mandatory labels of GM products, "USDA certified organic" labels imply GM-free products. But for the zero-tolerance consumers, this is not enough. They contend that nothing short of a "GM-free" label would be adequate.

Rationale and Objectives

The biggest debate regarding agricultural biotechnology is the labeling of GM food products. In the U.S., consumers and consumer-advocacy groups

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are concerned about implementing a mandatory labeling program for all genetically modified food products regardless of the product's health-related significance. Meanwhile, food producers support the current Food and Drug Administration (FDA) policy that mandatory labeling is required only when the nutritional content has changed or when there is a *de minimis* risk of an allergenic reaction to consumers. Numerous studies have been conducted regarding consumers' perceptions of genetically modified food products. However, fewer studies have evaluated producers' perceptions of the labeling of GM food products. Do producers behave as consumers do when it comes to labeling GM food products? Based on data from a survey of agricultural producers in ten Southern states, this study contributes to the understanding of how producers perceive mandatory labeling of GM food products.

Consumer-advocacy groups are on the zero-tolerance end of the risk spectrum, believing there is a need for full information on the labels of GM products. Consumer-advocacy groups' position is based on distrust of the FDA's GM food-products policy. Advocates seek complete disclosure of GM ingredients on mandatory labels. U.S. consumers generally prove to be much more flexible and open to information on both fronts. Producers' support of current FDA policies may vary more than is currently documented, and their perceptions of biotech products remain unclear because little is known and documented about their stand on the issue. Knowledge of how producers perceive mandatory labeling of genetically modified products has significant policy implications in terms of future food production, consumption, and trade.

As previously stated, this study focuses on agricultural producers from ten Southeastern states. The goal is to determine producers' perceptions in this region and to understand the source of their perceptions. The region's centrality to markets and favorable climate warrant this focus. Specifically, this study profiles producers' opinions about and perceptions of biotechnology and GM food products, farmers' demographics, and farm-enterprise characteristics and it compares these profiles to characterize those who would and would not require or favor mandatory labeling for GM food products. The general working hypothesis is that demographic characteristics and the perceived limitations and benefits of biotechnology have no significant impact on the producers' perceptions regarding mandatory labeling of genetically modified food products.

Conceptual Framework

The idea of an acceptable level of risk implies the existence of some standard or tolerance against which the risk is to be judged. Any tolerance level higher than zero implies the willingness to accept some level of risk. Knutson and Flinchbaugh (1998) and Archibald (1988) represented tolerance levels or acceptable levels of risk on a continuum from the zero-tolerance option to the risk-benefit option. This measurement scale was developed and utilized by displaying various degrees of acceptance of risk. The zero-tolerance starting point on this continuum is rooted in the 1958 "Delaney Clause" (Knutson and Flinchbaugh 1998, p. 430), a zero-tolerance standard meaning the "product should be completely devoid of scientific evidence indicating specific harmful substances have been directly or indirectly added to the food supply." The Delaney Clause became known as an unworkable standard (Knutson, 1998).

Next on the Archibald's acceptable-levels-of-risk continuum as adapted by Knutson and Flinchbaugh comes *reasonable certainty of no harm*. In 1996, the Food Quality Protection Act developed or adopted this approach, requiring the establishment of a threshold at which there are discernable health effects. This threshold has not been interpreted, and several more-tolerant and unworkable standards have evolved since 1958. The *de minimis or negligible risk* level also stemmed from the Delaney Clause, which unfolded between 1985 and 1988 (Holloway and Rowell 1996). The specific *de minimis* tolerance level was established as one in one million, meaning that an additive or residue could not cause more than one additional death per million people over their lifetime.

The next level of risk on the Archibald continuum is *no significant risk*. In 1986, the California Safe Drinking Water and Toxic Enforcement Act adopted this position of one in 100,000, implying one death per 100,000 people over their lifetime.

Finally, there is the *risk-benefit* approach, which takes into account the economic, social, and environmental costs and benefits. This is the one stan-

dard that recognizes the social aspect as well as the economic aspect by measuring both the risks and benefits (Knutson and Flinchbaugh 1998). Thus this position may be viewed as occupying the opposite end of the risk-tolerance continuum from mandatory labeling (see Figure 1).

Data and Methodology

A survey was developed in 2002 and tested on a sample portion of the population. The questionnaire consisted of 32 questions relating to various aspects of the producers' understanding of and attitudes toward agricultural biotechnology. The background-information questions for the producers included demographics such as gender, race, age, education, hours worked, acres owned, production on operation, gross value of sales, percentage of household income from all sources, interest in future workshops, and name and contact number. Other questions in the survey solicited information on the familiarity of producers with biotechnology, sources of information about biotechnology, benefits and limitation of biotechnology, assistance to starting biotechnology application, and a matrix of producer opinions about biotechnology.

The population for this survey comprised farmers from ten states: Alabama, Louisiana, Texas, Oklahoma, Florida, Mississippi, Tennessee, South Carolina, Arkansas, and Georgia. The study is based on survey data collected by the Southern Agbiotech Consortium for Underserved Communities (SACUC) to determine farmers' understanding of and attitudes toward agricultural biotechnology.

Two sub-samples of farmers were drawn, one from "under-served" counties and another from the remaining "better-served" counties. The Pennsylvania Credit Union League (PCUL 2001) defines underserved counties as an area within an Enterprise Zone under the Internal Revenue Code; an area where the percentage living in poverty is at least 20 percent; an area outside of a Metropolitan area where the median family income is at or below 80 percent of the statewide or national non-Metropolitan area median family income, whichever is greater; or an area where the unemployment rate is at least 1.5 times the national average. The selection of the underserved counties in this study is consistent with the above definition. The state office of the USDA's National Agricultural Statistics Service (USDA-NASS) in Alabama was then contracted to conduct or administer the survey for the Consortium (SACUC 2002).

The logistic regression model was selected in this analysis because of its asymptotic characteristics which constrain the predicted probabilities

Illustrative Continuum of Tolerance Options for Food Safety

|----------|----------|

(1)		*(0)*
Zero tolerance	*De Minimis*	*Risk/Benefits*
Mandatory labeling	(1 in 1 million)	**Voluntary labeling**
Consumer advocacy groups & Concerned citizens	FDA policy Some producers & consumers	FDA policy
---------less risk ----------		---------more risk---------

Totally agree "1"……..……Totally disagree "0"

The range of the continuum scale is based on the dependent variable: "Biotech food labeling should be mandatory. "

Figure 1. Risk-Tolerance Continuum for Food Safety by Archibald (1988) and Adapted by Knutson and Flinchbaugh (1998).

to between the range of 0 and 1. The logit model is commonly used in settings where the dependent variable is binary. Because the data source provided is based on individual rather than grouped observations, the common estimation method is the maximum likelihood (Gujarati 2003), which has the beneficial characteristic of producing consistent and asymptotically efficient parameters (Pindyck and Rubinfeld 1998).

The conceptual framework presented in Figure 1 is based on total agreement with mandatory labeling versus at least some reservations on opinions about and preference for mandatory labeling of GM food products. This necessitated the binary coding of the dependent variable. BLABEL was coded as "0" for farmers who had at least some reservations and "1" for those who were in total agreement with mandatory labeling of GM food products. Given that BLABEL can equal either 0 or 1, the logistic probability distribution was therefore assumed, and defined as

$$(1)\quad \text{Prob}(BLABEL = 1) = \frac{e^{X\beta}}{1 + e^{X\beta}},$$

where BLABEL is as previously defined, X is a vector of explanatory variables that may influence a producer's perception of agricultural biotechnology, and β is a vector of coefficients to be estimated. Equation 2 is the general model that was specified and used to empirically estimate and predict the probability of a producer favoring mandatory labels on GM food products:

$$(2)\quad \text{BLABEL} = \beta_0 + \beta_1\text{DEMOGR} + \beta_2\text{BENEFT} + \beta_3\text{LIMITN} + \beta_4\text{STATES} + \beta_5\text{PRODUC} + \beta_6\text{INFOSC} + \beta_7\text{UNDERSC} + \varepsilon,$$

where DEMOGR represents demographic variables, BENEFT represents whether biotechnology has benefited or will benefit the farming operation, LIMITN represents the limitations that would prevent one from using more (any) biotechnology, PRODUC represents enterprises currently produced by farmers (cotton, beef cattle, hay, etc.), INFOSC represents information sources (newspaper, magazines, radio, television), STATES represents each of the ten states within the SACUC consortium, UNDERSC defines whether a county was underserved or not, and ε is an error term with zero mean and constant variance. The other variables are as previously defined.

The variable UNDERSC was included to test whether a difference in perceptions existed between producers within and outside underserved areas. Similarly, the STATES variable was included to test if differentiated opinions or responses existed among the ten states. Thus in addition to the aforementioned distinction, the model specified takes into account producers' demographics, benefits and limitations of biotechnology, the type of production enterprises in which producers are engaged, and information sources.

Empirical Results and Discussion

The maximum-likelihood estimates of the model are shown in Table 1. A number of statistical problems had to be overcome in this model, many of which related to multicollinearity or high correlation among explanatory variables. Some variables within a sub-group had to be excluded from model to deal with these problems. For instance, because of the problems, not all demographic variables were used. Similarly, not all benefits or limitations variables were included in the model. The selection or exclusion of variables from the model was accomplished through stepwise or block (forward likelihood ratio) logistic regression. Extra care and personal judgment was employed to make sure relevant variables were not excluded even though they may have been statistically insignificant. This was done because statistically insignificant variables still contained important information. The variables are defined in Table 2.

As shown in Table 1, approximately 63 percent of the observations for all producers are correctly predicted, and 16 of the 40 variables in the model are statistically significant at the ten-percent level or better. The chi-square test of the measure of the overall significance of the model with 40 degrees of freedom is approximately 193.78 and is significant at the five-percent level. Thus we reject the hypothesis that benefits and limitations of biotechnology do not significantly influence producers' perceptions of mandatory labels on genetically modified food products.

The GROSSR variable is statistically significant at about one-percent level, suggesting that producers whose gross value of sales income is at least

Table 1. Logistic Regression Results for Mandatory Labeling of Genetically Modified Food Products.

Variable	Parameter estimate	Standard error	Change in probability	P-value
Intercept	1.103	0.315	0.206	0.000
AGE4690	0.008	0.153	0.002	0.957
COLLEGE	-0.395*	0.110	-0.095	0.000
GENDER	-0.505*	0.184	-0.119	0.006
RACE	0.290	0.187	0.071	0.120
NEWSPAP	0.074	0.105	0.018	0.484
MAGZI	-0.214*	0.103	-0.053	0.037
RADIOTV	-0.030	0.106	-0.007	0.780
HEALTHL	-0.415*	0.140	-0.099	0.003
WETGAI	-0.208**	0.128	-0.051	0.104
NOINFO	0.332*	0.119	0.081	0.005
NOLAND	-0.044	0.131	-0.011	0.738
DONTLK	1.496*	0.241	0.224	0.000
GROSSR	-0.303*	0.109	-0.074	0.005
UNDERSC	0.075	0.106	0.019	0.479
N. CAROLINA	-0.840*	0.235	-0.177	0.000
MISSISSIPPI	-0.605*	0.221	-0.138	0.006
OKLAHOMA	-0.401**	0.231	-0.096	0.083
TENNESSEE	-0.425**	0.239	-0.102	0.075
GEORGIA	-0.301	0.230	-0.074	0.190
ALABAMA	-0.299	0.202	-0.073	0.140
ARKANSAS	-0.278	0.251	-0.068	0.268
TEXAS	-0.261	0.228	-0.064	0.252
LOUISIANA	-0.254	0.232	-0.062	0.274
GRAINSOI	-0.037	0.157	-0.009	0.813
NUSGREH	-0.221	0.248	-0.055	0.374
VEGMEL	0.287	0.193	0.070	0.137
COTTON	-0.769*	0.270	-0.166	0.004
FRUITNTB	-0.227	0.149	-0.056	0.129
GARDENHM	0.233**	0.125	0.057	0.062
HAY	0.188**	0.107	0.047	0.079
OTHCROP	-0.108	0.218	-0.027	0.621
BEFCAT	0.006	0.117	0.001	0.958
POULEGGS	-0.385	0.245	-0.093	0.115
SHEGTSWO	0.545*	0.225	0.127	0.015
DAIRY	0.099	0.505	0.025	0.844
HOGS	-0.272	0.315	-0.067	0.388
AQUACUL	-0.278	0.268	-0.068	0.299
TIMBERCR	-0.129	0.113	-0.032	0.253
EQUINE	0.297*	0.149	0.073	0.046
LIVSTKPO	-0.145	0.236	-0.036	0.539
Cox & Snell R-square	0.098			
Log-Likelihood	2422.004			
Chi Square	193.780			
Corrected prediction	62.700			

* indicates parameter significant at 0.05 level or better.

** indicates parameter significant at 0.10 level.

Responses to the question "Biotech food labeling should be mandatory" are coded as "1" for totally agree and "0" for at least some reservations.

Table 2. Definitions of Varilables.

Variables	Definitions
AGE4690	1 if age is 46–90 years and over; 0 otherwise
COLLEGE	1 if some college; 0 otherwise
GENDER	1 if male; 0 otherwise
RACE	1 if Minorities (blacks, Hispanics, & other); 0 otherwise
NEWSPAP	1 if information source is newspaper; 0 otherwise
MAGAZIN	1 if information source is magazines; 0 otherwise
RADIOTV	1 if information source is radio/television; 0 otherwise
HEALTHL	1 if benefit is healthier livestock/poultry; 0 otherwise
WETGAIN	1 if benefit is faster weight gains for livestock/poultry; 0 otherwise
NOINFOR	1 if limitation is "not enough available information"; 0 otherwise
NOLAND	1 if limitation is "not enough land"; 0 otherwise
DONTLKB	1 if limitation is "I don't like biotech"; 0 otherwise
GROSSR	1 if gross value sales is ≥ $10,000; 0 otherwise
UNDERSC	1 if underserved counties; 0 otherwise
NORTH CAROLINA	1 if North Carolina; 0 otherwise
MISSISSIPI	1 if Mississippi; 0 otherwise
OKLAHOMA	1 if Oklahoma; 0 otherwise
TENNESSE	1 if Tennessee; 0 otherwise
GEORGIA	1 if Georgia; 0 otherwise
ALABAMA	1 if Alabama; 0 if otherwise
ARKANSAS	1 if Arkansas; 0 otherwise
TEXAS	1 if Texas; 0 otherwise
LOUISIANA	1 if Louisiana; 0 otherwise
FLORIDA	1 if Florida; 0 otherwise
GRAINSOI	1 if Grains and Oilseeds enterprise; 0 otherwise
NUSGREH	1 if Nursery, Greenhouse & floriculture enterprise; 0 otherwise
VEGMEL	1 if Vegetables & melons enterprise; 0 otherwise
COTTON	1 if Cotton enterprise; 0 otherwise
FRUITNTB	1 if Fruits, nuts, & berries enterprise; 0 otherwise
GARDENHM	1 if Garden for home use; 0 otherwise
HAY	1 if Hay enterprise; 0 otherwise
OTHCROP	1 if Other crops enterprise; 0 otherwise
BEFCAT	1 if Beef cattle enterprise; 0 otherwise
POULEGGS	1 if Poultry & eggs enterprise; 0 otherwise
SEGTSWOO	1 if Sheep, goat, wool & mohair enterprise; 0 otherwise
DAIRY	1 if Dairy enterprise; 0 otherwise
HOGS	1 if Hogs enterprise; 0 otherwise
AQUACUL	1 if Aquaculture enterprise; 0 otherwise
TIMBERCR	1 if Timber (including CRP); 0 otherwise
EQUINE	1 if Equine enterprise; 0 otherwise
LIVSTKPO	1 if Other livestock & poultry enterprises; 0 otherwise
UNDERSC	1 if underserved counties; 0 otherwise

$10,000 are less likely to agree to mandatory labeling and want to sell more of their produce on a larger scale. On the other hand, small agricultural producers with marginal gross sales or smaller volumes of products may not care for an expanded market. As a result, it is reasonable to expect the small producers (and not the large volume producers) to favor mandatory labeling of GM products.

The education variable (COLLEGE) was positive and statistically significant at the one-percent level of significance, implying that producers with at least a college education are less likely to favor mandatory labeling of GM products. The age and race variables do not significantly influence producers' decisions to choose mandatory labeling, thereby failing to reject the hypothesis that demographic characteristics do not influence producers opinions about and preferences for mandatory labeling.

Consistent with the literature, Knutson and Flinchbaugh (1988) observed that the well- or better-informed farmers usually apply a cost-benefit perspective. They trust the government labeling policy but do not believe additional regulation is necessary. Various studies have also concluded that higher levels of education lead to increasing levels of information search (Katona and Muller 1995; Schultz 1975; Nayga 1996). Similarly, Archibald (1988) observes that the well-informed are against labeling of GM products because of the associated cost. They acknowledge the risk but rationalize that the benefits outweigh the risk. Various other studies have also concluded that higher levels of education lead to increasing levels of information search (Katona and Muller 1995; Schultz 1975; Nayga 1996).

The fact that the variable UNDERSC is statistically insignificant suggests that there is no significant statistical difference in perceptions with respect to GM product labeling between producers within and outside the underserved counties.

The gender variable is negative and statistically significant at the one-percent level of significance, suggesting the probability of male producers not favoring mandatory labels on GM products. This finding is consistent with previous studies and may reflect the fact that women rather than men are the primary household shoppers and are concerned with what they and their families consume. One would therefore expect differences in perceptions between male and female producers. Males are less likely to use food labels (Nayga 1996); females may be more likely to use nutritional labels because gender roles encourage them to place more importance on food selection (Guthrie et al. 1995). These results would suggest that farm producers behave as consumers do when it comes to decisions about GM food products. This is less surprising given that producers, in almost all cases, are also consumers.

Finally, information-source variables NEWSPAP and RADIOTV were statistically insignificant, suggesting that these sources do not significantly influence whether or not producers favor mandatory labeling of GM food products. However, the MAGAZN variable is negative and statistically significant, suggesting that producers who read and obtain information from agricultural magazines (i.e., *Progressive Farmer*, *Agricultural Research*, etc.) are less likely to favor mandatory labeling of GM food products. These results are consistent with the literature (Kirchhoff 2001). For instance, in Oregon there was much propaganda through these sources of information about labeling of biotech products, but the final decision was about 71 percent against mandatory labeling. These results may suggest that once consumers or producers look past the mass media and consumer advocates, they weigh the benefits and risk/costs of mandatory labeling.

This study finds that male producers, college graduates, larger producers, and those who recognize benefits (specifically, health of livestock) have reservations about mandatory labeling, while hobby farmers (equine, sheep, and goats) and those voicing limitations such as lack of available information, dislike for biotechnology, and lack of enough land more frequently "totally agree" with mandatory labeling. After adjustments for all other variables, producers in North Carolina, Mississippi, Oklahoma, and Tennessee are less likely to insist on mandatory labels. Relatively more non-food crops may make a difference in these states. Producers in states with major food crops (rice, fruits, and vegetables) were more favorable toward mandatory labeling.

The negative sign of demographic variables (education, gender, and gross value of sales) and benefits variables have significant implications in relation to the conceptual framework. The results suggest that male producers, educated producers, or those with gross value of sales above $10,000 and those who view biotechnology as beneficial

are moving away from the zero-tolerance end of the risk-tolerance continuum (see Figure 1). These producers are evaluating the risks or costs and benefits of mandatory labeling. In this case, the benefits outweigh the risks or costs, forcing the producers to not support mandatory labeling. The significant and positive sign of the limitations variables has the opposite effect and implications. That is, producers who don't like biotechnology, don't have enough land, or think there isn't enough available information about biotechnology are concerned only about the risks or costs. They don't have reason to care about the benefits, and as a result they advocate mandatory labeling (zero tolerance).

Conclusion

The overall goal of this study was to analyze factors influencing producers' perceptions and opinions regarding mandatory labeling of biotech food products. The analysis involved a number of descriptive statistics, followed by the estimation of a logistic regression model. The working hypothesis in the analysis was that producers' perceptions regarding mandatory labeling were not influenced by producers' demographic characteristics, limitations and benefits of biotechnology, enterprise characteristics, sources of information, and whether a county was underserved or better served. We also hypothesized that there are no state differences in producer's opinions regarding labeling of genetically modified food products.

The study has highlighted a number of important findings with significant implications. It reveals that most of the farmers in the ten states are older (average is 58 years) and have some college education but remain part-time farmers, dependent largely on off-farm income for their livelihood. The majority raise beef cattle or produce hay and timber (includes enrollment in the Conservation Reserve Program). Most producers are in favor of mandatory labeling even though only half of the respondents totally agree with it. They believe biotech will benefit larger farmers and that farmers will be dependent on large corporations that develop and market biotechnology inputs. The majority are neutral about whether consumers will accept biotech crop products. They also remain undecided about government's ability to properly regulate biotechnology.

Gender, education, limitations and benefits of biotechnology, information sources (magazines only), and enterprise characteristics significantly influence producers' probability of being in favor of mandatory labeling. However, information sources such newspaper and radio and television, race, age, and whether a county was underserved do not significantly affect producers' perceptions regarding mandatory labeling of GM food products. That demographic characteristics (gender, education, and gross value of sales) and benefits (healthier livestock/poultry) are negative and statistically significant has important implications regarding the conceptual framework. These results suggest that these producers are not in favor of mandatory labeling. In other words, they are moving away from the zero-tolerance end of the risk-tolerance continuum shown in Figure 1. This suggests that such producers are evaluating the risks and costs and the benefits of mandatory labeling. In this case, the benefits seem to outweigh the risks and costs, causing these producers not to favor mandatory labeling. Similarly, the significant and positive sign of the limitation variables (i.e., don't like biotech, not enough land, and not enough available information) implies that these producers don't care about the benefits. They are only concerned about the risk, hence the decision to advocate mandatory labels on GM food products.

Benefits (healthier livestock/poultry) significantly decrease the probability of producers favoring mandatory labeling. As pointed out earlier, most livestock producers believe that biotechnology is beneficial since it entails cheaper feed and a shorter fattening period for their poultry/eggs or livestock in general. Also, when producers evaluate an innovation that is beneficial to their operation they are more likely to embrace that innovation. These results suggest that producers are evaluating these benefits, causing them to move from zero tolerance of mandatory labeling closer to the voluntary-labeling (risk/benefit) side of the continuum depicted in Figure 1.

Mississippi, Oklahoma, Tennessee, and North Carolina were negative and statistically significant. The implications of these results are unclear, but the authors speculate that this may reflect the fact that these states were non-food commodities producing states. For instance, Tennessee is known for cotton production, which might explain why Tennessee producers are less likely to favor mandatory label-

ing. As long as a product is not intended for human consumption, producers do not seem to perceive the real risk of biotechnology. As a result, producers of such commodities are less likely to agree to mandatory labeling.

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