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Public Policy and Endogenous Beliefs: The Case of Genetically Modified Food

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When individuals have limited information and are uncertain about the quality of a good, government policy, or the lack thereof, can serve as a signal to consumers about the likelihood of realizing alternative states of nature. In this paper, we focus on a controversial market characterized by uncertainty and for which consumers have diverse beliefs about government intervention: the market for genetically modified food. Data from a mail survey were used to estimate an econometric model where beliefs about labeling policy, beliefs about the safety of genetically modified food, and willingness to consume genetically modified food are endogenously determined. Results indicate that consumers who believe the government has a mandatory labeling policy for genetically modified food are more likely to believe genetically modified food is unsafe than consumers who believe no such policy is in place.

Key words: biotechnology, food labeling policy, genetically modified food, trivariate probit

Introduction

The assumption of exogenous preferences has proven valuable in the theory of social choice as alternative policies, institutions, and market structures can be compared in terms of welfare without having to worry about the effect of policy or market structure on preferences.[1] However, in the context of choice under risk, it is commonplace to assume people make decisions based on subjective probabilities and that these subjective probabilities are influenced by accumulated information and various signals (e.g., Savage, 1954). When people have limited information and are uncertain about the safety or quality of a good, government policy, or the lack thereof, can potentially serve as a signal to consumers about the likelihood of realizing alternative states of nature. That is, people may update their beliefs about the quality of a good once they learn about government actions. People's tastes (i.e., preferences for certain acts or outcomes) might remain stable, as is traditionally assumed; however, beliefs (i.e., subjective probabilities about the likelihood of observing an outcome) change with accrual of information. Because demand curves depend on beliefs, it is possible that changes in policy induce changes in demand—a factor which would complicate traditional types of welfare analysis.

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[1] Some authors have argued that cultural and evolutionary processes determine preferences, thereby making them endogenous (Bowles, 1998), and others argue changes in institutions and government policy alter preferences (e.g., Huck, 1998; Pollack, 1978; Marschak, 1978). Such studies represent a significant challenge to traditional welfare analysis.

In this paper, we focus on a controversial market characterized by uncertainty and for which consumers have diverse beliefs about government intervention: the market for genetically modified (GM) food. The purpose of this paper is to empirically investigate whether individuals' beliefs about government policies regarding mandatory GM food labeling are related to beliefs about the safety of GM food and willingness to consume GM food.

Several studies have shown that consumer demand and willingness to pay for GM food are responsive to new signals about safety and quality. For example, Kalaitzandonakes, Marks, and Vickner (2004) found that media coverage surrounding the Starlink corn incident in the United States had a statistically significant effect on demand for taco shells. Rousu et al. (2004) and Lusk et al. (2004) have shown, in experimental auctions, that consumers' willingness to pay for GM food is affected by information statements about the benefits and risks of GM food, and Rousu et al. (2004) showed that these effects were influenced by the presence of verifiable third-party information. Lusk et al. (2004) and Huffman et al. (2007) concluded that responses to information signals provided in experiments depend on people's prior knowledge levels.

Collectively, these studies suggest people's beliefs about the safety and quality of GM food are somewhat malleable and are affected by external signals about the safety and quality of GM food. This prior research has revealed how the media and information statements can influence demand for GM food. However, it is an open question as to whether changes in beliefs about *policy* alter demand for GM food, and the answer to this question has important ramifications for applied welfare analysis related to the effects of GM food policies on consumer welfare.

A number of papers have constructed theoretical models to identify the determinants of the welfare effects of GM food adoption, labeling, and trade policies. These studies indicate that consumer preference for GM food is a key determinant of the welfare ranking of various policies (e.g., Crespi and Marette, 2003; Fulton and Giannakas, 2004; Giannakas and Fulton, 2002; Lapan and Moschini, 2004; Lence and Hayes, 2005; Nielsen, Thierfelder, and Robinson, 2003). Other studies have experimentally elicited consumer demand for GM food and have used the estimates to draw inferences about the welfare effects of alternative policies (e.g., Lusk et al., 2005; Noussair, Robin, and Ruffieux, 2004). However, all of these studies have treated consumer demand for GM food as exogenous to policy. For example, underlying consumer willingness to pay for non-GM versus GM food is assumed to remain the same with or without a labeling policy. To our knowledge, Artuso (2003) is the only researcher to construct a conceptual model where demand for GM food is determined, in part, by legislation. Empirically determining whether demand for GM food is independent of present and future policies is critical as the debate on appropriate regulation of biotechnology moves forward.

In this paper, we show that consumers' beliefs about the safety of GM food are affected by beliefs about whether the federal government currently has a mandatory GM food labeling law, and that safety beliefs in turn affect stated willingness to consume GM food. Our analysis explicitly accounts for the fact that beliefs about policy and beliefs about safety might be endogenously determined. Based on evidence provided by our results, future theoretical and empirical work need to take seriously the possibility that the very act of creating a new policy may make the policy relatively more or less desirable.

Background and Conceptual Considerations

The primary objective of this paper is to investigate whether and how consumers' beliefs about the existence of a mandatory labeling policy relate to people's willingness to consume GM food. Beliefs about policy are conceptualized as affecting demand through their effect on beliefs about the safety of GM food. In particular, changes in beliefs about policy are hypothesized to serve as signals about the safety of GM food.

Background

There are a number of reasons to believe that actions on the part of policy makers, such as the enactment of a mandatory food labeling law, might serve as a signal of the safety and quality of a new technology such as GM food. First, anecdotal evidence from interest groups suggests a common perception that policy could influence beliefs about safety. For example, many agricultural groups in the United States strongly oppose mandatory GM food labels because of the contention that consumers will interpret the label as an indication that food produced through biotechnology is different and not as safe as food produced through traditional means (e.g., see Biotechnology Industry Organization, 2008). In stark contrast, however, the European Union Commissioner for Health and Consumer Protection has argued that GM food labels "should give consumers greater confidence" in GM food (Alvarez, 2003). Zepeda, Douthitt, and You (2003) similarly argued, in the context of labels on rbST milk, that the existence of labels lowers risk perceptions as labels give consumers the power of choice, thereby reducing the "outrage" of involuntarily consuming a risky food. Thus, although both sides of the debate disagree on the consequences of a labeling policy, they are apparently in agreement that biotechnology labels would influence beliefs about the safety of GM food.

Furthermore, recent research suggests more than 75% of U.S. citizens believe decisions about technology should be left to experts rather than based on the views of the public (Gaskell et al., 2005). These findings imply a majority of U.S. individuals trust experts' determination of the safety and quality of food. The federal government directly and indirectly finances a wealth of research and employs thousands of scientists. Thus, when the government reaches a decision about a policy, it is reasonable to assume its own experts and funded research are brought to bear on the problem. This would suggest then that individuals might interpret policy as a decision by experts whom, as previously noted, the public is willing to let establish safety and quality. Finally, even if one is unwilling to believe that policy is the result of experts' decisions and is instead the result of public opinion and politics, a number of studies suggest individuals are, perhaps rationally, willing to accept a group's consensus regarding the appropriateness of an action or product (e.g., Milgrom, Bickman, and Berkowitz, 1969). This so-called "social proof" would imply that the government's willingness to approve the sale of GM food, for example, might serve as proof of the technology's quality and safety.

Our argument is that policy can serve as a signal about the safety of GM food; however, as just discussed, the direction or content of the signal might be positive or negative. A mandatory label could serve as a safety warning or as a confirmation of the safety of GM. It is important to recognize that the U.S. federal government has at its disposal a number of options to regulate food when safety and quality are uncertain. At one extreme, the government can ban products deemed too unsafe, e.g., products produced with certain pesticides such as DDT. For other products, the government permits the sale of cigarettes, tobacco, and alcohol, but requires warning labels about adverse health consequences. Similarly, the U.S. government permits the sale of fish and ground beef, but requires statements about the harmful effects of mercury and undercooked meat. The government requires nutritional labels whereby firms must label potentially harmful substances such as trans-fatty acids. Likewise, the U.S. government often permits voluntary labels such as "heart healthy," "no growth hormones," etc. Consequently, there are degrees of food safety risk and it appears the government regulates accordingly—sometimes with bans, sometimes with mandatory labels, sometimes with voluntary labels, and sometimes with no action at all.

Believing the government imposes a mandatory labeling policy on GM food could be consistent with a belief that GM food is perhaps not as safe as traditional food, but it is not so unsafe that GM food should be completely banned. Depending on a consumer's prior beliefs about the safety of GM food, the imposition of mandatory labeling could be taken to imply GM food is safer than previously thought (in the case where one's prior was that GM food is so unsafe it should be banned) or might be taken to imply GM food is riskier than previously thought (in the case where one's prior is that GM food is safe enough to warrant no labeling at all).

In this paper, attention is focused on the question of mandatory labeling because voluntary labeling is already allowed. It is important to note that any findings related to the relationship between beliefs about mandatory labeling and beliefs about the safety of GM food need not correspond to the case of voluntary labels, which might send a different sort of signal to consumers. While the relationship between beliefs about voluntary labeling and beliefs about the safety of GM food is interesting in its own right, this is an issue we leave to future research. Further, findings among U.S. consumers regarding whether mandatory labels serve as a positive or negative signal may be very different from European and other consumers who are likely to have different priors.

Conceptual Considerations

We assume consumers have some belief about the safety of GM food, which can be represented by a subjective probability indicating the likelihood with which one believes consumption of GM food yields no adverse outcome. This subjective probability of safety depends on accumulated information and signals (e.g., Savage, 1954). The argument we put forth is that beliefs about labeling policy serve as a signal about the safety of GM food.

People differ in their beliefs about labeling policy as a result of differences in education, exposure to media, and so on. People also differ in terms of how these beliefs about labeling policy influence beliefs about GM safety. A Bayesian perspective suggests that when people encounter beliefs about GM safety differing from their own, say from encountering new information about the existence or lack thereof of labeling policies, they adjust their prior beliefs to arrive at a new posterior belief. As shown by Viscusi (1989) and Liu, Huang, and Brown (1998), these changes in beliefs depend on the relative weights people assign to their prior beliefs and the new information.

Social psychology literature suggests individuals tend to reject external information on topics about which they feel knowledgeable (Vertzberger, 1990; Frewer, 2003). Accordingly, Lusk et al. (2004) and Huffman et al. (2007) argue that the weights attached to priors can be approximated by people's subjective knowledge about GM food. Where do people's priors come from? Economic theory provides no answers to this question, but fortunately, a number of empirical regularities have been found. Two demographic variables have regularly been shown to influence people's priors about the safety of new food technologies: *Gender* and *Age*. Several studies suggest females and older individuals believe controversial food technologies and pathogens are less safe compared to beliefs held by males and younger individuals (e.g., Dosman, Adamowicz, and Hrudey, 2001). Further, differences in the way the two genders view and weight probabilities/beliefs could also cause different risk perceptions. In particular, Fehr-Duda, de Gennaro, and Schubert (2004) report that men and women perceive probabilities differently, with females overweighting low probability events more than males. In this context, such a result would imply that for the same objective probability of GM food being unsafe (a low probability event), females would overweight such a belief relative to males. Taken together, these arguments imply that beliefs about the safety of GM food can be written as:

(1) *Beliefs About the Safety of GM Food =*
f(Subjective and Objective Knowledge of GM Food, Gender, Age,
Beliefs About Mandatory GM Labeling Policy).

As shown by equation (1), beliefs about the safety of GM food depend on subjective and objective knowledge, which serve as proxies for the weight people assign to their priors. Gender and age are hypothesized to proxy for people's prior beliefs about GM food safety. Finally, given the argument that beliefs about GM labeling policy might serve as a safety signal, this variable is also included in equation (1).

Although equation (1) states that beliefs about the safety of GM food depend on beliefs about GM mandatory labeling policy, these two beliefs might be jointly determined. Specifically, although we have argued that differences in beliefs about policy might serve as signals which influence beliefs about safety, causality might run in the reverse direction. For example, individuals might believe their own perceptions about safety of GM food are similar to others in the population and thus believe the government would enact policies consistent with their and others' viewpoint. With this perspective, it is beliefs about the safety of GM food that serve as a signal about the likelihood of a particular policy being in place. Hence, we can construct an equation similar to the expression in (1) representing beliefs about the existence of a mandatory labeling policy:

(2) *Beliefs About Existence of Mandatory Labeling Policy on GM Food =*
f(Subjective and Objective Knowledge of GM Food, Knowledge of
GM Food Policy, Exposure to Information on Labeling Policy,
Beliefs About Safety of GM).

In equation (2), we omit the demographic variables included in equation (1) as there is no a priori expectation or empirical evidence to suggest age or gender relate directly to beliefs about labeling policy. Because of the simultaneity in equations (1) and (2), equation (2) needs to include at least one variable not present in equation (1) for identification purposes. Here, we rely on two variables. First, equation (2) posits that people's general knowledge of GM food policy will influence beliefs about the existence of a mandatory GM labeling policy. Although it might not be initially obvious, increased policy knowledge need not relate to safety beliefs, as evidenced by the host of activist groups on both sides of the issue (e.g., American Farm Bureau, Greenpeace, Friends of the Earth, etc.) with intense policy knowledge attempting to alter GM food regulation in one way or another. Thus, the argument is that policy knowledge primarily affects beliefs about the existence of a mandatory labeling policy and not beliefs about safety.

Second, equation (2) also includes exposure to information on labeling policy specifically. Here, we utilize the respondent's location to identify a group of people who have had relatively more exposure to information about GM labeling policies than most consumers. In particular, in 2002, Oregonians voted on a statewide ballot initiative to require mandatory labeling of GM foods. Prior to the vote, a number of publicity campaigns were launched by proponents and opponents of the policy. These campaigns are likely to have influenced individuals' beliefs about labeling policies. Indeed, the very act of placing the initiative on the ballot would serve to inform individuals that no such law was in place. Publicity surrounding the vote included both promotions and denouncements of the safety of GM, thus indicating the primary effect of the election likely influenced people's beliefs about policy, not safety.

Finally, as widely acknowledged and assumed in the literature on food safety, people's perceptions of the safety (or riskiness) of food will influence people's willingness to buy, consume, and pay for the food (e.g., Hayes et al., 1995; Lusk et al., 2006). Therefore, willingness to buy and consume GM food is written as:

(3) *Willingness to Buy and Consume GM Food =*
f(Beliefs About the Safety of GM Food, Gender, Age, Income).

Equation (3) shows that willingness to consume GM food is a function of beliefs about the safety of GM food.[2] Of course, it is not just beliefs that influence behavior, but outcomes as well—i.e., the expected utility from consuming a good is the subjective probability of a safe outcome times the utility derived from the safe outcome.

The outcome of interest in this case relates to health, and the variables *Age* and *Gender* are included as they are hypothesized to relate to the marginal utility of health (e.g., see Nayga, 1996). The *Income* variable is included because it relates to the marginal utility of income, which is hypothesized to influence food demand. Equation (3) does not directly include knowledge of GM food. Some previous studies have identified a link between subjective knowledge and willingness to pay for GM food. This study allows for such a link, but through its effect on beliefs about the safety of GM food. Within the conceptual framework of a Bayesian decision maker, knowledge and information will affect beliefs, and beliefs, in turn, will influence behavior.

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[2] Consumers may be concerned about other issues when deciding whether to purchase GM food, such as the effects on the environment or ethical considerations. These factors could be readily incorporated into this framework by adding arguments to equation (3). We abstract away from these issues to simplify the analysis. See also studies by Lusk et al. (2006) or Onyango, Nayga, and Schilling (2004) showing that while willingness to pay for GM food is strongly influenced by perceptions of risk, it is unaffected by ethical or environmental concerns, perhaps because such issues represent public goods unlikely to be influenced by a single individual's choice. Further, this study focuses on the effect of a new signal, such as a policy change, on beliefs about the safety of GM food and tracks this change in safety beliefs to changes in willingness to consume. Assuming the signal does not also affect ethical considerations or perceptions of environmental risks, there is no confounding effect in identifying the impact of the signal on willingness to consume.

Ultimately, it is an empirical question as to whether policy beliefs, in fact, serve as signals about the safety of GM food as indicated in equation (2). It is also an open question as to whether the "signal" represented by the labeling policy has a negative or positive effect on perceptions of the safety of GM food. In what follows we describe the approach taken to test these hypotheses.

Methods and Data

There are a variety of approaches we considered utilizing to investigate the relationship between policy and safety beliefs. One approach is to compare demand prior to the enactment of a policy to demand elicited after a policy is implemented either indirectly by use of time-series data on purchasing behavior or directly through survey or experimental elicitation. The difficulty with this approach is that there is a plethora of confounding factors, many of which are difficult or impossible to measure, which might influence individual behavior in the time it takes a policy to come to fruition. For example, several studies have shown differences in U.S. and European consumer acceptance of GM food, but because there are so many competing hypotheses regarding why these differences exist, it would be virtually impossible to conclusively demonstrate that the differences in acceptance are a result of differences in public policies toward GM food.

An alternative research method would entail recruiting a sample of uninformed individuals, splitting them into two treatment groups, and comparing safety perceptions between these treatment groups where information has been provided about two competing policy scenarios. Unfortunately, this approach would involve deception in at least one of the treatments, a practice strongly discouraged by most experimental economists due to concerns regarding the long-term consequences of deceitful research practices that might undermine the credibility of future data collection efforts (e.g., see Davis and Holt, 1993).

A similar experimental approach might involve taking a group of people who have incorrect beliefs about policy and: (*a*) measure their preferences, (*b*) inform them of the policy that is actually in place, (*c*) re-measure their preferences, and (*d*) compare how preferences change after the participants are informed that the policy is different than what they actually believed. There are several problems, however, with such a research design. As discussed in the conceptual section, people will assign some weight to new signals they receive. Thus, even if people were told the actual policy in place is something different than what they believe, subjects must discern whether the signal can be trusted and whether they should assign some weight to it. Further, the fact that a university researcher is sending the signal might very well be interpreted as conveying meaningful content about the signal. Such an experimental approach, with a researcher providing a signal, is very different from a circumstance where individuals receive signals in their natural context, from friends, co-workers, media, etc. Finally, with this approach, respondents might change their behavior to conform to what they believe are the researcher's expectations.

The approach taken in this study is to pick a good for which there is a natural diversity of beliefs about government policy in the population and compare individuals with one set of beliefs to individuals with competing beliefs while controlling for other measures of objective and subjective knowledge. This study compares food safety beliefs across people who have, for varied reasons, different beliefs about policy while using econometric methods to control differences in other characteristics across individuals. Specifically, we compare differences in willingness to consume GM food across people who have different beliefs in labeling policy, but who are "otherwise identical." We construct this "otherwise identical" condition by controlling for factors like education, gender, income, subjective knowledge, and policy knowledge in a regression framework. That is, instead of the experimental approach of testing for a treatment effect (which in this case is the effect of believing or not believing in a labeling policy) by randomly assigning people to different treatments, we utilize the econometric approach to estimate the treatment effect holding constant other variables.

Data Collection Instrument

A mail survey was developed to measure individuals' beliefs about GM food policy, beliefs about GM food safety, and willingness to consume GM food. The survey was sent to a random sample of 2,500 U.S. households in the fall of 2004. Post cards reminding individuals to complete the survey were sent approximately one week after the initial mailing, and individuals who had not responded after two weeks were sent a follow-up letter and another copy of the survey. A total of 545 surveys were returned. After adjusting for surveys returned due to undeliverable addresses, a 25% response rate was achieved. After further removing individuals from the sample who did not complete all survey questions, we were left with 501 usable observations. As described below, sample weights were constructed to force the sample to match the U.S. general population in terms of income and education. The survey was relatively brief and was constructed to measure the variables discussed in the conceptual section.

Measurement of Endogenous Variables

As noted in the previous section, there are three endogenous variables: (*a*) beliefs about the safety of GM food, (*b*) beliefs about the existence of mandatory GM labeling, and (*c*) willingness to consume GM food. To measure individuals' beliefs about the safety of GM food, participants were asked to respond to the true/false/uncertain question, "By eating genetically modified corn, a person's genes could also be changed." The question was taken from Gaskell et al. (1999) who argued that for this type of question, "an incorrect answer was presumed to reflect both a lack of scientific knowledge and an image of threatening possibilities of food adulteration, infection, and monstrosities" (p. 386). Thus, this question measures knowledge and beliefs about the safety of GM food. With a single true/false question such as this, it is difficult if not impossible to separate what constitutes a belief from "knowledge." The key observation is that individuals answer this true/false question with a response they believe to be true. It is reasonable to assume that if respondents believe eating GM corn will alter their genes, then they believe eating GM food to be unsafe.[3]

[3] Of course, a person might believe GM food is unsafe in a way other than by changing genes. Our question measures a particular safety belief.

We use the response to this question to represent people's latent beliefs about the safety of GM food. Let y_1 denote an individual's observed response to this question, where y_1 takes the value of 1 if the individual believes the statement is false (e.g., GM is safe) and 0 if the individual believes the statement is true or is uncertain (e.g., GM is potentially unsafe). The observed variable, y_1, is assumed to relate to people's latent, unobserved safety beliefs, y_1^*, whereby $y_1 = 1$ if $y_1^* \geq 0$, and $y_1 = 0$ if $y_1^* < 0$.

Second, individuals were asked to state their beliefs about whether the government enforced a mandatory labeling policy for GM food. In particular, participants were asked to respond to the true/false/uncertain question, "U.S. federal law requires foods that contain a certain level of genetically modified ingredients to be labeled as such." Let y_2 denote an individual's response to this question, where y_2 takes the value of 1 if the individual believes the statement is true (e.g., the government requires labeling of GM food) and 0 if the individual believes the statement is false or uncertain. As before, the observed variable, y_2, is assumed to relate to people's latent, unobserved beliefs about the existence of a mandatory labeling policy, y_2^*, whereby $y_2 = 1$ if $y_2^* \geq 0$, and $y_2 = 0$ if $y_2^* < 0$.

The third endogenous variable required a measure of consumer willingness to consume GM food. For a more robust analysis, we utilized two different measures. In particular, we measured individuals' stated willingness to eat and purchase GM food.[4] The first willingness to consume/purchase measure was created by asking people to respond to the following three statements on a seven-point scale (where 1 = strongly disagree and 7 = strongly agree): (*a*) "I am willing to eat genetically modified food," (*b*) "I am willing to buy genetically modified food," and (*c*) "I am willing to serve my family genetically modified food." These questions are similar to those used, for example, in studies conducted by Oyango, Nayga, and Schilling (2004) and Saba and Vassallo (2002). Responses to each of these three questions were summed for each individual to create a variable we denote as *Buy*. The second willingness-to-consume measure was created following the approach taken by Lusk and Sullivan (2002). Individuals were asked to indicate whether they would eat a series of seven different GM vegetables that had "an extra gene from the same vegetable," "an extra gene from a different vegetable," "an extra gene from a bacterium," etc. A variable *Eat* was created, consisting of the sum of the number of GM vegetables the individuals said they would eat.

A drawback to these two measures is that they relate to *stated* preferences for GM food. A number of studies have shown that individuals tend to overstate willingness to pay in hypothetical valuation settings as compared to when real money is being considered (e.g., Cummings, Harrison, and Rutström, 1995). We side-step this issue by focusing on a more qualitative measure of preference as indicated by responses to scale questions related to willingness to eat and consume GM food. Although stated and revealed preferences are often found to be statistically different, the two measures are frequently highly correlated. For example, Loureiro, McCluskey, and Mittelhammer (2003), in a study comparing hypothetical purchase statements to actual purchases in a grocery store, concluded "a consumer who states they would pay a premium for a product is more likely to actually purchase the product" (p. 53). Our measures relate to people's stated intentions to consume and buy GM food, and some of the most widely used models in marketing and psychology argue that such intentions are perhaps the best predictors of actual behavior available (e.g., Fishbein and Ajzen, 1975).

[4] Willingness to consume is directly related to willingness to pay, assuming unit demand and a fixed price.

Let an individual's response to the willingness-to-consume question be denoted by y_3, which takes the value of 1 if the person's score on *Eat* or *Buy* was higher than the sample median. For example, if the analysis uses *Eat* as the measure of willingness to consume GM food, then y_3 takes the value of 1 if a person's measure of *Eat* exceeds the sample median value for *Eat*, and 0 otherwise. Converting the variables *Eat* and *Buy* into dichotomous choice variables is consistent with the notion that the decision of whether to eat or buy GM food is ultimately a dichotomous decision. The dependent variables in our estimations are latent variables, related to the propensity of people's willingness to consume or not consume. We concede this conversion of the dependent variable fails to make full use of the information contained in the measured variables, and perhaps introduces some measurement error; however, this conversion unifies our presentation of the econometric model with little effect on the overall conclusions stemming from the analysis.

Measures of Exogenous Variables

Subjective knowledge was elicited by asking individuals to self-describe their knowledge of the facts and issues concerning genetic modification in food production on a seven-point scale where 1 = "not at all knowledgeable" and 7 = "extremely knowledgeable." Overall education was measured by asking individuals to indicate the highest level of education attained, and a dummy variable was constructed identifying those individuals who had attained at least an undergraduate degree. The education question was asked on the last page of the survey along with questions about gender, age, and income.

As indicated previously, two variables expected to influence beliefs about government labeling policy (y_2) but not directly beliefs about GM food safety (y_1) are knowledge about GM food policies and media exposure/location. To construct the first variable, individuals were asked the three additional true/false/uncertain questions regarding GM food policies: (*a*) "The U.S. government has restricted imports of some types of genetically modified foods from other countries," (*b*) "Genetically modified foods are currently sold in grocery stores," and (*c*) "Food regulatory agencies have approved the sale of certain genetically modified foods in the U.S."

A policy knowledge variable was constructed by giving one point for each question answered correctly and subtracting one point for each question answered incorrectly, generating a variable with a maximum (minimum) possible value of +3 (−3). Survey respondents were also asked to indicate the state in which they resided, and a dummy variable was created identifying those individuals who were residents of Oregon.[5]

Econometric Model

A structural econometric model for the three dependent variables in question is written as follows:

[5] We also conducted our analysis using a dummy variable identifying people who either reside in Oregon or in a state directly adjacent to Oregon. We obtained very similar results in terms of the sign and statistical significance if this variable was used instead of the Oregon dummy variable.

$$\text{(4)} \qquad \begin{aligned} y_1^* &= \gamma_1 y_2^* + \mathbf{X}_1\beta_1 + \varepsilon_1, \\ y_2^* &= \gamma_2 y_1^* + \mathbf{X}_2\beta_2 + \varepsilon_2, \\ y_3^* &= \gamma_3 y_1^* + \mathbf{X}_3\beta_3 + \varepsilon_3, \end{aligned}$$

where

$$\begin{aligned} y_1 &= 1 \text{ if } y_1^* > 0;\; y_1 = 0 \text{ otherwise}, \\ y_2 &= 1 \text{ if } y_2^* > 0;\; y_2 = 0 \text{ otherwise}, \\ y_3 &= 1 \text{ if } y_3^* > 0;\; y_3 = 0 \text{ otherwise}, \end{aligned}$$

and where ε_1, ε_2, and ε_3 are distributed trivariate normal with means zero and unit standard deviations with correlation coefficients ρ_{12}, ρ_{13}, and ρ_{23}; y_1^*, y_2^*, and y_3^* are latent variables representing, respectively, the propensity to believe that GM food is safe, the propensity to believe that the government requires labeling of GM food, and willingness to consume. $\mathbf{X}_1$, $\mathbf{X}_2$, and $\mathbf{X}_3$ are matrices composed of variables hypothesized to influence y_1^*, y_2^*, and y_3^*, respectively. In particular, the columns in $\mathbf{X}_1$ contain a constant and the following variables: *Subjective Knowledge*, *Education*, *Age*, and *Gender*. The columns in $\mathbf{X}_2$ contain a constant and the following variables: *Subjective Knowledge*, *Education*, *Policy Knowledge*, and *Oregon*. Finally, the columns in $\mathbf{X}_3$ contain a constant and the following variables: *Age*, *Gender*, and *Income*.

As described by Maddala (1983, pp. 117–125), in order to identify the parameters γ_1 and γ_2, $\mathbf{X}_1$ must contain at least one variable not in $\mathbf{X}_2$ and vice versa. We accomplish this identification by including the GM policy knowledge variable and the location variable in the y_2^* equation, but not in the y_1^* equation. Given the discussion in the conceptual section, these variables are most likely to relate to beliefs about the existence of GM labels, but beliefs about the safety of GM are hypothesized to be uninfluenced by these factors. Conversely, based on the literature on food safety and health, the demographic variables *Age* and *Gender* are assumed to influence only safety beliefs (y_1^*), and not beliefs about labeling (y_2^*). Because the relationship between y_1^* and y_3^* is recursive, γ_3 is identified.

Maddala (1983) and Amemiya (1978) suggest two-step procedures for estimating the structural parameters of models such as the one outlined above; however, their approaches are typically restricted to two-equation models. Thus, we rewrite (4) in terms of the reduced-form equations and estimate the system of equations by maximum likelihood. The use of full-information maximum likelihood is more efficient than the two-step procedures and allows for direct estimation of the coefficient standard errors (e.g., see Maddala, 1983, p. 252).

In what follows, we extend the approach taken by Aradhyula and Tronstad (2003) from the bivariate probit to a trivariate probit. The reduced form for the structural model is given by:

$$\text{(4)} \qquad \begin{aligned} y_1^* &= w_1 + u_1, \\ y_2^* &= w_2 + u_2, \\ y_3^* &= w_3 + u_3, \end{aligned}$$

where

$$
\begin{aligned}
w_1 &= (\mathbf{X}_1\beta_1 + \gamma_1\mathbf{X}_2\beta_2)/(1-\gamma_1\gamma_2),\\
w_2 &= (\mathbf{X}_2\beta_2 + \gamma_2\mathbf{X}_1\beta_1)/(1-\gamma_1\gamma_2),\\
w_3 &= \gamma_3 w_1 + \mathbf{X}_3\beta_3,\\
u_1 &= (\varepsilon_1 + \gamma_1\varepsilon_2)/(1-\gamma_1\gamma_2),\\
u_2 &= (\varepsilon_2 + \gamma_2\varepsilon_1)/(1-\gamma_1\gamma_2),\\
u_3 &= \varepsilon_3 + \gamma_3\left[(\varepsilon_1 + \gamma_1\varepsilon_2)/(1-\gamma_1\gamma_2)\right],\\
y_1 &= 1 \text{ if } y_1^* > 0;\ y_1 = 0 \text{ otherwise},\\
y_2 &= 1 \text{ if } y_2^* > 0;\ y_2 = 0 \text{ otherwise},\\
y_3 &= 1 \text{ if } y_3^* > 0;\ y_3 = 0 \text{ otherwise}.
\end{aligned}
$$

Because ε_1, ε_2, and ε_3 are normally distributed, this implies u_1, u_2, and u_3 are also normally distributed as follows:

$$
(6)\qquad \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{11}^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_{22}^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_{33}^2 \end{pmatrix}\right],
$$

where

$$
\begin{aligned}
\sigma_{11} &= \sqrt{(1 + \gamma_1^2 + 2\rho_{12}\gamma_1)/(1-\gamma_1\gamma_2)^2}\,,\\
\sigma_{22} &= \sqrt{(1 + \gamma_2^2 + 2\rho_{12}\gamma_2)/(1-\gamma_1\gamma_2)^2}\,,\\
\sigma_{33} &= \sqrt{1 + 2\gamma_3(\gamma_1\rho_{23} + \rho_{13})/(1-\gamma_1\gamma_2) + \gamma_3^2(1 + \gamma_1^2 + 2\gamma_1\rho_{12})/(1-\gamma_1\gamma_2)^2}\,,\\
\sigma_{12} &= \left(\gamma_1 + \gamma_2 + \rho_{12}(1 + \gamma_1\gamma_2)\right)/(1-\gamma_1\gamma_2)^2,\\
\sigma_{13} &= (\gamma_3 + \gamma_1^2\gamma_3 + 2\rho_{12}\gamma_1\gamma_3)/(1-\gamma_1\gamma_2)^2 + (\rho_{13} + \gamma_1\rho_{23})/(1-\gamma_1\gamma_2),\\
\sigma_{23} &= \left(\gamma_1\gamma_3 + \gamma_2\gamma_3 + \rho_{12}(\gamma_3 + \gamma_1\gamma_2\gamma_3)\right)/(1-\gamma_1\gamma_2)^2 + (\rho_{23} + \gamma_2\rho_{13})/(1-\gamma_1\gamma_2).
\end{aligned}
$$

The structural parameters β_1, β_2, β_3, γ_1, γ_2, and γ_3 can be estimated along with the correlation parameters ρ_{12}, ρ_{13}, and ρ_{23} using maximum-likelihood techniques.

To construct the likelihood function, the probability of each of the eight possible outcomes of the dependent variable must be specified. Let $\Phi_3(\cdot)$ denote the trivariate standard normal cumulative distribution function where the first three arguments in parentheses represent means and the latter three arguments represent correlations:

$$
\begin{aligned}
(7)\quad P_1 &= \text{Prob}(y_1 = 1, y_2 = 1, y_3 = 1) = \Phi_3(w_1/\sigma_{11}, w_2/\sigma_{22}, w_3/\sigma_{33}, r_{12}, r_{13}, r_{23}),\\
P_2 &= \text{Prob}(y_1 = 1, y_2 = 1, y_3 = 0) = \Phi_3(w_1/\sigma_{11}, w_2/\sigma_{22}, -w_3/\sigma_{33}, r_{12}, -r_{13}, -r_{23}),\\
P_3 &= \text{Prob}(y_1 = 1, y_2 = 0, y_3 = 0) = \Phi_3(w_1/\sigma_{11}, -w_2/\sigma_{22}, -w_3/\sigma_{33}, -r_{12}, -r_{13}, r_{23}),\\
P_4 &= \text{Prob}(y_1 = 1, y_2 = 0, y_3 = 1) = \Phi_3(w_1/\sigma_{11}, -w_2/\sigma_{22}, w_3/\sigma_{33}, -r_{12}, r_{13}, -r_{23}),\\
P_5 &= \text{Prob}(y_1 = 0, y_2 = 1, y_3 = 1) = \Phi_3(-w_1/\sigma_{11}, w_2/\sigma_{22}, w_3/\sigma_{33}, -r_{12}, -r_{13}, r_{23}),
\end{aligned}
$$

$$P_6 = \text{Prob}(y_1 = 0, y_2 = 0, y_3 = 1) = \Phi_3(-w_1/\sigma_{11}, -w_2/\sigma_{22}, w_3/\sigma_{33}, r_{12}, -r_{13}, -r_{23}),$$
$$P_7 = \text{Prob}(y_1 = 0, y_2 = 1, y_3 = 0) = \Phi_3(-w_1/\sigma_{11}, w_2/\sigma_{22}, -w_3/\sigma_{33}, -r_{12}, r_{13}, -r_{23}),$$
$$P_8 = \text{Prob}(y_1 = 0, y_2 = 0, y_3 = 0) = \Phi_3(-w_1/\sigma_{11}, -w_2/\sigma_{22}, -w_3/\sigma_{33}, r_{12}, r_{13}, r_{23}),$$

where $r_{12} = \sigma_{12}/\sigma_1\sigma_2$, $r_{13} = \sigma_{13}/\sigma_1\sigma_3$, and $r_{23} = \sigma_{23}/\sigma_2\sigma_3$. The likelihood function for each individual is given by:

$$(8) \qquad L = P_1^{y_1y_2y_3} P_2^{y_1y_2(1-y_3)} P_3^{y_1(1-y_2)(1-y_3)} P_4^{y_1(1-y_2)y_3} P_5^{(1-y_1)y_2y_3} P_6^{(1-y_1)(1-y_2)y_3} \times P_7^{(1-y_1)y_2(1-y_3)} P_8^{(1-y_1)(1-y_2)(1-y_3)}.$$

The parameters are estimated by maximizing the log of equation (8) summed across the N individuals in the sample.

Results

Table 1 reports summary statistics and definitions for variables used in the econometric models. The sample was comprised of more men than women and the individuals in the sample had slightly higher incomes and were more educated than the U.S. general population. To correct for differences in the sample and the population, post-stratification weights were created based on 2003 household income and education data from the U.S. Census Bureau. We chose these two variables because these are variables for which the U.S. Census Bureau reports cross-tabulations and because education is likely to be highly related to one of the key variables of interest in this study—knowledge of GM food (*Subjective Knowledge*).

To create weights, we placed each respondent into one of six income categories and one of two education categories (no college degree/college degree) making a total of 12 categories. Weights were created by dividing the frequency of individuals in the U.S. population in each of the 12 categories (as reported by the Census Bureau) by the fraction of individuals in the survey sample who fell in each of the 12 categories. To illustrate the effect of the weights on results, table 1 reports weighted and unweighted means of the variables used in the analysis. (Note: once weights were applied to the data, the mean education and income match those of the general population.) Because the weighted statistics are more reflective of the population, all results reported in the remaining analysis utilize the derived weights.

Table 1 also reports responses to knowledge and belief variables. About 69% of respondents stated a belief consistent with the view that GM food is safe, i.e., they responded "false" to the question, "By eating GM corn, a person's genes could be changed." As expected, there was significant diversity in individuals' beliefs about the presence of mandatory GM labels. About 45% of individuals believed a mandatory labeling policy was in place, whereas 21% did not believe such a policy existed, and another 34% were uncertain about the presence of a mandatory labeling policy. Most individuals rated themselves toward the bottom of the subjective knowledge scale, with a mean rating of 2.86 out of a maximum possible rating of 7. Despite this, individuals performed reasonably well on the policy knowledge quiz, with the average individual scoring about 0.89 (on a scale ranging from –3 to +3) regarding their knowledge of government policies toward GM food.

Table 1. Summary Statistics and Definitions of Variables (N = 501)

Variable	Definition	Unweighted Mean[a]	Weighted Mean[b]
Gender	1 if female; 0 if male	0.367 (0.483)	0.411 (0.493)
Age	Respondent's age in years	54.202 (16.371)	55.064 (16.707)
Education	1 if respondent attained B.S. degree or higher; 0 otherwise	0.525 (0.500)	0.286 (0.452)
Income	Annual household income in $1,000s	67.533 (45.837)	58.015 (44.695)
Belief that GM Food Is Safe (y_1)	1 = response of "false" to the true/false/uncertain question "By eating GM corn, a person's genes could also be changed"; 0 otherwise	0.735 (0.442)	0.692 (0.462)
Belief that the Government Mandates GM Labels (y_2)	1 = response of "true" to the true/false/uncertain question "U.S. federal law requires foods that contain a certain level of GM ingredients to be labeled as such"; 0 otherwise	0.435 (0.496)	0.452 (0.498)
Subjective Knowledge	Stated knowledge of facts and issues concerning genetic modification in food production (1 = not at all knowledgeable; 7 = extremely knowledgeable)	3.000 (1.361)	2.863 (1.330)
Policy Knowledge	Score on three-question policy quiz (3 = all questions answered correctly; –3 = all questions answered incorrectly)	1.010 (1.196)	0.895 (1.162)
Oregon	1 = Oregon resident; 0 otherwise	0.014 (0.117)	0.013 (0.113)

Note: Values in parentheses are standard deviations.
[a] Sample means prior to application of weights that adjust sample characteristics to match the U.S. general population.
[b] Means calculated using weights that adjust sample characteristics to match the U.S. general population.

Summary statistics and definitions for the variables measuring willingness to consume GM food are presented in table 2. On average, people responded with a score of 4.03 (on a scale of 1 = strongly disagree to 7 = strongly agree) to the statement, "I am willing to eat genetically modified food." Responses to the other two scale questions were similar, with mean outcomes falling almost exactly at the center value on the 7-point scale. Table 2 also shows that, on average, individuals indicated they would eat 2.8 of the seven vegetables with an extra gene(s). The correlation between *Eat* and *Buy* is 0.67, implying that while the measures are related, they appear to be measuring slightly different dimensions of preference for GM food.

Table 3 reports the estimates of the structural model outlined in equation (5) obtained by maximizing the likelihood function in equation (8). These estimates account for the endogeneity of safety beliefs and policy beliefs and for the correlation between these two variables and willingness to consume. Two models are shown in table 3: model 1 in which y_3^* corresponds to responses to *Buy*, and model 2 in which y_3^* corresponds to *Eat*. Overall, the two models fit the data reasonably well. The hypothesis that all model parameters are equal to zero is strongly rejected for both models according to a likelihood-ratio test. The McFadden R^2 values are somewhat low, which is common in cross-sectional discrete choice models of this sort. The predictive performance of the estimated models is reasonable. In model 2, for example, the estimated model correctly predicts

Table 2. Summary Statistics and Definitions of Variables Characterizing Willingness to Consume and Pay for Genetically Modified Food (N = 501)

Variable / Question	Mean [a]	Standard Deviation
Response to . . .		
[1 = strongly disagree; 7 = strongly agree]		
▸ I am willing to eat genetically modified food	4.033	1.795
▸ I am willing to buy genetically modified food	3.956	1.818
▸ I am willing to serve my family genetically modified food	3.875	1.821
Buy [sum of responses to above three items]	11.854	5.367
y_3 = 1 if *Buy* > median response (median = 12); 0 otherwise	0.390	0.489
Fraction of respondents indicating they would eat a vegetable with . . .		
[1 = would eat; 0 = would not eat]		
▸ an extra gene from the same vegetable	0.773	0.419
▸ an extra gene from a different vegetable	0.617	0.487
▸ several extra genes from a different vegetable	0.527	0.500
▸ an extra gene from a bacterium	0.253	0.435
▸ an extra gene from a fungus	0.257	0.438
▸ an extra gene from a virus	0.173	0.379
▸ an extra gene from an animal	0.237	0.426
Eat [no. of items individual would eat: 0 = would eat none; 7 = would eat all]	2.837	2.345
y_3 = 1 if *Eat* > median response (median = 3); 0 otherwise	0.315	0.465

[a] Means calculated using weights that adjust sample characteristics to match the U.S. general population.

or classifies 74% of labeling belief responses, 60% of safety belief responses, and 61% of the *Eat* responses.

Estimates reveal that beliefs about a mandatory labeling policy have a statistically significant effect on beliefs about the safety of GM food in both model specifications presented in table 3. In particular, individuals who are more likely to believe a labeling policy is in place are less likely to believe GM food is safe. This result is consistent with the argument of many agricultural producer groups that the imposition of GM food labels would serve as a signal indicating there is something inferior about GM foods relative to non-GM food. Although policy beliefs affected safety beliefs, the reverse was not true; apparently causation only runs in one direction. This finding is consistent with the view that policy beliefs serve as a signal about the safety of GM food.

Consistent with expectations and previous literature, older and female respondents were less likely to believe GM food is safe; however, the latter result is only significant at the p = 0.12 level of significance. Those consumers with higher levels of subjective knowledge were more likely to believe GM food is safe and that a mandatory labeling policy exists. It is unclear exactly why increased subjective knowledge was associated with an increased likelihood of believing that a mandatory labeling policy exists; however, it is important to note this is a ceteris paribus effect holding constant policy knowledge, education, and location, all of which, as expected, have a significantly negative effect on the belief that a mandatory labeling policy exists. Specifically, individuals who had a college degree were less likely to believe the government has a mandatory labeling policy, as were individuals who scored higher on the policy knowledge test.

Table 3. Structural Parameters from Trivariate Probit Models

	Model 1[a]		Model 2[b]	
Variable	Estimate	Std. Error	Estimate	Std. Error
Dependent Variable = y_1^* (*Belief that GM Food Is Safe*):				
Constant	0.397	0.325	0.405	0.328
Subjective Knowledge	0.210***	0.048	0.223***	0.045
Education	–0.056	0.152	–0.144	0.120
Age	–0.011***	0.004	–0.011***	0.004
Female	–0.141	0.089	–0.141	0.091
y_2^* (*Belief that Mandatory Labeling Exists*)	–0.625***	0.156	–0.617***	0.142
Dependent Variable = y_2^* (*Belief that Mandatory Labeling Exists*):				
Constant	–0.320**	0.144	–0.317**	0.143
Subjective Knowledge	0.174***	0.055	0.176***	0.057
Education	–0.316**	0.144	–0.329**	0.134
Policy Knowledge	–0.150**	0.061	–0.159**	0.063
Oregon	–0.772*	0.401	–0.619**	0.305
y_1^* (*Belief that GM Food Is Safe*)	–0.174	0.266	–0.165	0.262
Dependent Variable = y_3^* (*Willing to Buy or Willing to Consume*):				
Constant	–1.063***	0.409	–1.739***	0.319
Female	–0.328*	0.176	–0.208	0.194
Income	0.008	0.006	0.014***	0.005
Age	0.002	0.002	0.002**	0.001
y_1^* (*Belief that GM Food Is Safe*)	0.858***	0.292	1.261***	0.230
Correlations:				
ρ_{12}	0.789***	0.169	0.780***	0.162
ρ_{13}	–0.035	0.254	–0.527***	0.195
ρ_{23}	0.168	0.218	–0.093	0.250
Log Likelihood, full model	–912.398		–865.652	
Log Likelihood, intercepts only	–989.201		–966.488	
χ^2 Statistic[c]	153.605***		201.673***	
McFadden's R^2	0.078		0.104	

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively. All regressions employ weights that adjust sample characteristics to match the U.S. general population; $N = 501$ for each regression.

[a] In Model 1, y_3 corresponds to whether *Buy* exceeds the median value.

[b] In Model 2, y_3 corresponds to whether *Eat* exceeds the median value.

[c] The 95% critical χ^2 value with 17 degrees of freedom (20 total parameters, 3 intercept terms) is 27.59.

Oregonians were, as expected, less likely to believe a mandatory labeling policy was in place when compared to other individuals, a result likely attributable to the increased exposure to the GM labeling issue in that state due to the ballot initiative in 2002.

Table 3 also reports the determinants of willingness to consume GM food. Beliefs about safety of GM food are significantly related to the two measures of willingness to consume GM food. In particular, people who were more likely to believe GM food was safe were significantly more willing to consume and eat GM food. In summary, people who believe the government enforces a mandatory labeling policy are less likely to be willing to purchase and consume GM food than are individuals who believe no such policy is in place.

Implications and Conclusions

This study empirically investigated whether individuals' beliefs about government policy were related to beliefs about the safety of genetically modified (GM) food and willingness to consume GM food. We found that individuals who believed the government imposed a mandatory labeling policy for GM food believed GM food was less safe and were less willing to eat and buy GM food than consumers who either believed no policy was in place or were uncertain on the matter. To the extent one is willing to interpret these results as suggesting that people's beliefs about the safety of GM food will change when labeling policy changes, an assumption we return to momentarily, a number of implications emerge.

In particular, it is instructive to consider the manner in which previous studies have carried out welfare analysis associated with various GM food policy options. Many theoretical studies that have investigated the welfare effects of GM food adoption and labeling have modeled consumer demand via the Mussa-Rosen (1978) framework, where the utility derived from consuming food is a function of expected quality and preferences for quality (see, e.g., Crespi and Marette, 2003; Fulton and Giannakas, 2004; Giannakas and Fulton, 2002; Lapan and Moschini, 2004; Lence and Hayes, 2005; Nielsen, Thierfelder, and Robinson, 2003). In this framework, when a country adopts GM food production (or allows GM imports), this has the effect of lowering the expected quality of food, thereby shifting the demand curve for food inward. The welfare effects of GM adoption (or allowing GM imports) depend on the size of the demand shift relative to the decrease in food cost resulting from the more efficient production made possible via biotechnology. Further, in these types of models, labeling policies serve to segment the market. In a market with no label, consumers make an assessment of the expected quality (safety) of the product on the market and make purchase decisions accordingly. With labels, consumers with stronger preferences for quality will buy the more expensive higher quality (safer) product, while other consumers purchase the lower quality product or do not purchase at all. The welfare effects of labeling policies depend primarily on the costs of labeling and the extent to which consumers differentiate between GM and non-GM foods. A key component of these studies is that consumers' demand for GM food is assumed constant regardless of which policy is in place.

This assumption may be ill-founded. The conventional modeling approach ignores the possibility that policies themselves serve as signals about the safety of GM food. When policies shift, willingness to pay for GM food may also shift. It is often difficult to know a priori the direction in which policies might influence willingness to pay for GM food; however, results from this study suggest that implementation of a particular policy—mandatory labeling—might serve to shift the demand curve for this product inward. One interpretation of this finding is that a cost-benefit analysis of a mandatory GM food labeling policy which did not control for individuals' beliefs about policy would likely underestimate the benefits of a label because ex ante estimates of willingness to pay and willingness to consume would imply less aversion to GM food than would ex post estimates. Elicited demand for a good prior to a policy may provide biased estimates of the welfare consequences which occur once the policy is enacted, as individuals' safety beliefs may change once the policy is changed. Welfare analysis itself becomes more complicated as judgment calls must be made about whether the benefits and costs of a policy should be measured relative to the ex ante or ex post demand curve. At a minimum, the results presented here suggest it would be worthwhile to carry out some type of consumer research to determine the size of the demand shift for judging the extent to which welfare calculations will diverge.

It is useful to interpret these results in light of differences in demand for GM food in Europe and the United States. Several studies have found substantial disparities between the United States and Europe in terms of differences in consumer demand for GM food (e.g., Lusk et al., 2006). Europe has been slow to approve GM crops for commercialization and has enforced a mandatory GM food labeling policy. By contrast, the United States has approved numerous GM crops for commercialization and has no mandatory labeling policy in place. The results of this study suggest that one possible contributor to the divergence in U.S. and EU demand for GM food is the difference in policies enacted across the Atlantic. The traditional view is that the differences in policies are a reflection of differences in demand for GM food, but the results presented here suggest the reverse could also be true.

An important caveat to such interpretations is that they presume the actions of government will change individuals' beliefs about the safety of GM food. Strictly speaking, however, what our analysis showed is that individuals' beliefs about the safety of GM food are related to *beliefs* about government policy—not the actual policy which is in place. Our results do not necessarily show what would happen if policy actually changed; nevertheless, it seems prudent to assume some individuals would change their beliefs about what policies are in place once a new rule is enacted. So long as all other factors were held constant, including knowledge of GM food and GM food policy, as was done in the regression analysis, our results suggest such a belief change would yield a change in demand for GM food. Future work on this issue might focus on identifying the mechanisms by which people update their beliefs about government policies once policies change. This initial work does suggest, however, that there is a potential for endogeneity of beliefs about food safety and policy, a fact which would greatly complicate the task of applied welfare analysis.

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