WILLINGNESS TO PAY VERSUS WILLINGNESS TO VOTE: CONSUMER AND VOTER AVOIDANCE OF GENETICALLY MODIFIED FOODS

GINA WATERFIELD, SCOTT KAPLAN, AND DAVID ZILBERMAN

Many technologies face disapproval from some portion of the general public due to perceived risks or externalities. Individuals can respond to these controversial technologies either as consumers by choosing favorable alternatives or as voters by supporting regulation. We examine the relationship between willingness to pay a premium for products that avoid a controversial technology and willingness to vote in favor of a ban or mandatory labeling, with a focus on how this relationship is influenced by income and perceived risks. In a survey regarding genetically modified (GM) food, we find that the majority of respondents make consumer and voter choices that can be explained by a standard utility maximization framework. However, certain respondent characteristics are correlated with inconsistent choice patterns. In particular, low-income voters appear to be overly supportive of regulation relative to their private willingness to pay. Voters who are uncertain about the safety of GM food also tend to be more in favor of regulation than their consumer choices would imply.

Key words: Ballot proposition, genetically modified food, labeling, voting, willingness to pay.

JEL codes: D11, D12, H75, Q18.

Many consumer goods are produced using controversial technologies that receive mixed acceptance from the general public due to perceived negative consequences or risks. The food industry has generated a particularly large number of these controversies, with examples including the application of pesticides, irradiation, and the use of artificial growth hormone in milk production (Lusk, Roosen, and Bieberstein 2014). The public's concerns often include private health risks associated with consumption but may also regard environmental or social externalities, as demonstrated by consumers' willingness to pay (WTP) for green or ethical goods such as dolphin-safe tuna (Teisl, Roe, and Hicks 2002) and fair-trade coffee (Loureiro and Lotade 2005), which offer no private benefits. Genetically modified (GM) food is a particularly controversial food production technology at present, with individuals and consumer groups expressing concern about both consumption safety and environmental risks despite broad scientific agreement that these fears are unsupported by evidence (Moschini 2008; NRC 2010; McFadden and Lusk 2015).

As with other controversial technologies, individuals can indicate their preferences regarding GM food both in the marketplace and at the ballot box in states that allow referendums. In the market setting, consumers can opt to pay a premium for food free from GM ingredients.[1] In the referendum setting, voters can choose to support more stringent regulation of GM food technology. The fact that individuals face real choices regarding GM food as both consumers and voters provides an opportunity to compare how a given individual makes decisions in both roles regarding the same good. People may behave differently and may perhaps have different preferences

Gina Waterfield, The Nature Conservancy. Scott Kaplan, Ph.D. Candidate, Department of Agricultural and Resource Economics, UC Berkeley. David Zilberman, Professor and Robinson Chair, Department of Agricultural and Resource Economics, UC Berkeley. Correspondence to be sent to: scottkaplan@berkeley.edu

[1] A large prior literature has sought to estimate consumer WTP for GM-free food, along with its demographic and contextual determinants (see Lusk et al. 2005 and Costa-Font, Gil, and Traill 2008) for summaries).

depending on the role in which they are acting (Hausman and McPherson 2006). Nyborg (2000) explores this idea specifically in the context of environmental valuation. Indeed, this consideration has been used to critique both environmental valuation methods that confound the two decision-making contexts (Blamey, Common, and Quiggin 1995; Sagoff 2007) and studies that infer policy preferences from consumer-based evidence (Hamilton, Sunding, and Zilberman 2003).

In this paper, we develop a conceptual model based on an expanded utilitarian framework where individuals have preferences with respect to prices, perceived environmental and social amenities, and freedom of choice. We compare the determinants of private WTP for GM-free food with those of support for three potential policies: voluntary labeling of GM-free food, mandatory labeling of GM food, and an outright ban on the use of GM technology in food production. Our approach yields testable hypotheses regarding consumer and voter choices based on individual preferences and perceptions. We then test these hypotheses using stated preference data, collected in the context of an actual ballot initiative regarding mandatory labeling. We compare stated willingness to pay a premium for GM-free food with stated willingness to vote in favor of mandatory labeling or a ban and then examine how different factors, in particular income and perceptions of the technology, affect these decisions differentially, determining whether or not they are consistent with our conceptual model.

Prior empirical evidence suggests that voter and consumer decisions do not necessarily align. Hamilton, Sunding, and Zilberman (2003) uses a survey to assess the relationship between WTP for pesticide-free food and voter support for a ban on pesticides. The authors find that although WTP factors into an individual's voting decision, consumer behavior on its own is not a strong predictor of voting decisions.[2] Brooks and Lusk (2012) and Alphonce, Alfnes, and Sharma (2014) use survey evidence on individual preferences over products derived from cloned animals and restaurant standards, respectively, again finding inconsistencies between voter support and consumer choices. This paper is the first, to the best of our knowledge, to study the issue of differing consumer and voter preferences in the context of GM foods.[3]

Our contribution to the broader literature is both theoretical and empirical. First, our conceptual framework clarifies the relationship among WTP, support for voluntary and mandatory labeling, and support for a ban. We rely on a straightforward utility maximization framework to formalize the relationship between WTP and voting decisions, assuming each individual has a single, consistent utility function underlying their consumer and voter decisions. Our theoretical model shows that WTP is of course not a perfect predictor of willingness to vote, as a single consumer who buys a good produced using a controversial technology makes only a marginal contribution to its associated risks or externalities. A vote in favor of regulation, however, marginally increases the probability that those risks or externalities will be limited. In addition, regulation may entail a loss in future consumer choices that the private purchase decision does not. We show instead that WTP is correlated with the probability of voting in favor of regulation but that the relationship is not smooth; WTP divides individuals into categories across which the relationship between voting probabilities and income differs.

Our empirical study is based around a 2012 California ballot initiative that proposed mandatory labeling of GM food. Mandatory labeling of GM foods has become a contentious ongoing debate, with many states having passed such initiatives and a federal regulatory standard superseding individual state mandates implemented in 2018.[4] Shortly before the election, we conducted an online survey of 715 California residents, eliciting respondents' WTP for

[2] Consistent with expectations, Hamilton, Sunding, and Zilberman (2003) find that individuals who receive large private benefits have high WTP, and their probability of voting for a ban is positively related to WTP. Individuals with strong environmental preferences may be likely to vote for a ban but have low private WTP. Strong preferences for freedom of choice are associated with high WTP but low likelihood of voting, due to option value.

[3] Prior studies have used WTP to gauge support for regulation of GM foods. Carlsson, Frykblom, and Lagerkvist (2007) conducted a survey of Swedish consumers, comparing WTP for non-GM food under mandatory labeling versus a ban. They find that WTP is not significantly higher under the ban after controlling for private benefits, concluding there is no welfare argument for a ban. Loureiro and Hine (2004) compare voluntary and mandatory labeling using a survey of Colorado shoppers, finding that respondents report higher WTP for mandatory compared to voluntary labeling but conclude that mean WTP for mandatory labeling is less than would be required to cover the costs of such a policy.

[4] Public Law 114-216, known as the National Bioengineered Food Disclosure Law, was signed into law on July 29, 2016 to "establish a national bioengineered food disclosure standard." States previously passing initiatives include Washington, Vermont, Connecticut, Maine, and the District of Columbia.

GM-free food, voting intentions with respect to the mandatory labeling proposition, and willingness to vote in favor of a hypothetical ban on GM ingredients.[5] Using a nonhypothetical, actual proposition scenario as context for the survey increased respondent familiarity with the issue, likely meaning our responses would be more similar to those of an actual vote.[6] Conducting the survey before the election also meant that responses would not be biased by the final outcome of the election.

Using the conceptual model to guide our econometric approach, we confirm that WTP depends positively on the perceived private benefits associated with consumption of GM-free food but only weakly positively on income. Interestingly, we also find that perceived environmental impacts of the technology appear to be a greater motivator of purchasing GM-free food than perceived risks to consumer health. Consistent with our model, we also find that both the decision to support mandatory labeling and the decision to vote in favor of a ban on GM food depend on WTP. However, consistent with the prior literature, we also find potential inconsistencies in consumer-voter decisions—in particular, a tendency for some voters to be more supportive of regulation than their consumer choices would suggest. Although poorer individuals tend to have lower WTP for non-GM products, the probability of voting in favor of regulation is either uncorrelated with or decreasing in income. We also find that the role of perceptions regarding the safety of GM food may be different among consumers and voters, with uncertainty tending to increase voter support for mandatory labeling and a ban, but decrease WTP.

The article proceeds as follows. The next section presents our conceptual framework and a summary of our testable hypotheses. The following section describes our survey instrument and provides summary statistics of the data collected. Next, we present our econometric analysis, motivated by the hypotheses developed in the second Section. The final section concludes.

[5] Although a revealed preference approach may be preferred if the objective is accurate estimation of the magnitude of WTP itself, our objective in this study is a comparison of WTP with willingness to support regulation. Moreover, the revealed preference data required to make such a comparison is not available at an individual level because voting is confidential.

[6] Hainmueller, Hangartner, and Yamamoto (2014) finds that individuals' answers to hypothetical questions are quite accurate when these questions are rooted in real-life situations.

Conceptual Framework

Although WTP for a good produced without use of a controversial technology and willingness to vote for more stringent regulation are both indicative of aversion to that technology, they are very different decisions. A consumer's individual purchase decision directly affects that consumer's private utility but has little impact on market-wide use of the technology. A voting decision, in contrast, is intended to affect market-wide use, although the probability of an individual vote having any impact is likewise minimal. Purchasing a product and changes in regulation also entail very different costs to individual consumers, and individuals as consumers face different constraints than individuals as voters.[7] The following framework provides some intuition on the relationship between WTP and willingness to vote in favor of voluntary labeling, mandatory labeling, and a ban, under the assumption that a given individual has a single utility function underlying both their consumer and voter decisions.

Consumer Behavior

Suppose that an individual can choose between two versions of a product, one produced using a controversial technology, in this case a product containing GM ingredients, and an alternative that avoids the technology and the associated perceived externalities or risks, in this case a non-GM product. Following Hamilton, Sunding, and Zilberman (2003), we assume a random utility model such that the relevant portion of an individual's utility under regulatory scenario *s* is:

$$(1)\qquad \boldsymbol{U_s} = \mathbf{V_s} + \boldsymbol{\epsilon}_\mathbf{s} = \boldsymbol{v}(\boldsymbol{X}, \boldsymbol{p_s}, \boldsymbol{r_s}, \boldsymbol{b_s}, \boldsymbol{f_s}) + \boldsymbol{\epsilon_s}$$

Where $\boldsymbol{X}$ represents a vector of individual characteristics including income, $\boldsymbol{p_s}$ is the price of the good including time spent searching for it, $\boldsymbol{r_s}$ represents the perceived private benefits of the chosen good, $\boldsymbol{b_s}$ the perceived public benefits associated with the overall level of consumption,[8] $\boldsymbol{f_s}$ a measure of consumer freedom of choice between various product alternatives, and $\boldsymbol{\epsilon_s}$ is randomly distributed with

[7] In this analysis we do not account for the actual costs associated with going out to vote or of supporting regulation.

[8] We say "perceived" private and public benefits to accommodate the fact that in the case of GM-free food these benefits are unsubstantiated and individuals' perceptions of them vary widely across the population (Lusk et al. 2004).

mean zero. Note that $\boldsymbol{b_s}$ depends on the purchasing decisions of all consumers in the market, and indeed we assume that the individual consumer's decision has no effect on $\boldsymbol{b_s}$. A consumer may, however, gain utility from simply making what she believes to be an ethical choice, akin to the "warm glow" of charitable giving (Andreoni 1990). We do not include a separate variable to capture this additional utility, as its provision is coincident with the provision of private benefits, but we note that $\frac{\partial v}{\partial r_s}$ may be a function of $\boldsymbol{b_s}$.[9]

We consider the representative portion of the consumer's utility under four different regulatory scenarios: no labeling (s = 0), voluntary labeling (s = 1), mandatory labeling (s = 2), and a ban on GM products (s = 3).[10] Normalizing price to 1 in the no labeling scenario and suppressing the $\boldsymbol{X}$ argument we have:

$$(2) \quad V_0 = v(1, r_0, b_0, f_0)$$

Where r_0 represents private benefits corresponding to purchase of the GM product, b_0 represents provision of public benefits when no one purchases the non-GM product, and f_0 denotes consumers' lack of freedom to choose between the two. Under voluntary labeling, an individual's utility is given by:

$$(3) \quad V_1 = \max\{v(1, r_0, b_1, f_1), v(1+\delta_1, r_1, b_1, f_1)\}$$

because she can choose between the GM product and non-GM product.[11] In the case of the former, she faces no increase in price or private benefits relative to scenario 0. In the case of the latter, price increases by δ_1 and private benefits increase to r_1, because we assume the non-GM product is at least as desirable in terms of private characteristics. Under either option, perceived public benefits increase to b_1, because some consumers purchase the non-GM product, and freedom of choice increases to f_1. Similarly, under mandatory labeling:

$$(4) \quad V_2 = \max\{v(1+\Delta_2, r_0, b_2, f_1), \\ v(1+\Delta_2+\delta_2, r_1, b_2, f_1)\}$$

Mandatory labeling is expected to affect the prices of both the GM and non-GM products. The fractional change can be decomposed into a common element, denoted by Δ_2, which is likely to be positive because of costs associated with supply chain management and monitoring and enforcement, as well as an additional element that only affects the price of the non-GM product, δ_2. This element is assumed to be weakly positive, reflecting higher production costs and constraints on the supply of the non-GM product. Following Costanigro and Lusk (2014) and McFadden and Lusk (2017), we assume that the labeling per se does not affect consumer preferences. Last, under a ban on the GM product, individual utility is given by:

$$(5) \quad V_3 = v(1+\delta_3, r_1, b_3, f_0)$$

where δ_3 represents the increase in price of switching entirely to the non-GM product, and b_3 denotes the corresponding change in the provision of public benefits. Freedom of choice reverts to f_0, since consumers in both the "no label" and "ban" scenarios are provided with only a single product choice.

Consumers may intuit that all prices increase as a result of regulation. In the case of voluntary labeling, the cost of separation, certification, and promotion of non-GM products is assumed by the producers of these products, although it is shared by all producers in the case of mandatory labeling (Lapan and Moschini 2004; Zilberman et al. 2014).[12] We denote this the "supply effect." Additionally, in both labeling cases, consumers can distinguish between GM and non-GM products, and so there is no differential demand effect for non-GM products across the two scenarios. Therefore, it is plausible to assume that the price premium on the non-GM product falls

[9] We present a static utility function for simplicity but recognize the temporal pattern of private and public benefits and costs associated with each of the considered scenarios. One interpretation is that $\mathbf{p_s}$, $\mathbf{r_s}$ and $\mathbf{b_s}$ are already given in present discounted value terms. Because we ask individuals about their environmental preferences, this may also indicate their time preferences and the relative weight they assign future environmental impacts versus immediate private impacts from purchasing.

[10] Although the idea of banning GM products has not made its way up to a vote or legislative decision in the U.S., many opponents advocate a ban on GM agricultural inputs, as has been implemented in some European countries (Genetic Literacy Project 2019). Even in those countries, however, people consume some products (e.g. meat and oil) that rely on GM inputs. There are also interest groups advocating for a complete ban on GMOs, for example the group "Sustainable Pulse" based in Europe. A full ban on GM products is therefore an important benchmark in assessing consumer preferences.

[11] In reality, it is unlikely that GM and non-GM versions of the exact same product exist. As Lancaster (1966) argues, consumers are interested in product characteristics rather than specific products, and the value of each alternative is made up of the hedonic values of their characteristics.

[12] The model presented in Lapan and Moschini (2004) is a trade model, whereas our experiment is a simpler setting. Their model assumes that with voluntary labeling, the producers of non-GM products are responsible for the costs associated with the labeling.

as we move from voluntary to mandatory labeling, namely $\Delta_2 + \delta_2 < \delta_1$. Given $\Delta_2 > 0$, this further implies $\delta_2 < \delta_1$, as we would expect. Under the ban, the price premium on non-GM products compared to the initial price, δ_3, is likely to be lower than the price premium under the two labeling scenarios due to reduced search cost and increased production efficiency resulting from sole reliance on non-GM varieties.

Provision of public benefits varies across the three scenarios because it depends on the purchasing decisions of the entire population. As regulation becomes more stringent, the non-GM product becomes relatively less costly, as discussed above, and therefore represents an increasingly large market share, up to the entire market under scenario 3. As the GM product represents a progressively smaller share of consumption and production, perceived public benefits increase, and we have $b_3 \geq b_2 \geq b_1 \geq b_0$. We also assume the partial derivatives of the utility function have the expected signs, namely $\frac{\partial v}{\partial p_s} < 0$ whereas all others are at least non-negative.

Assuming consumers are utility maximizing, willingness to pay under scenarios 1 and 2 are the solutions, δ_1^* and δ_2^*, to the following equalities:

$$(6) \quad v(1, r_0, b_1, f_1) = v(1 + \delta_1^*, r_1, b_1, f_1)$$

$$(7) \quad v(1 + \Delta_2, r_0, b_2, f_1) = v(1 + \Delta_2 + \delta_2^*, r_1, b_2, f_1)$$

Replacing both sides of the above equations with linear approximations of v yields the following expression for WTP:

$$(8) \quad \boldsymbol{\delta_1^* = \delta_2^* = \delta^*} = -\frac{\partial \boldsymbol{v}}{\partial \boldsymbol{r_s}}(\boldsymbol{r_1} - \boldsymbol{r_0}) \Big/ \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p_s}}$$

WTP thus depends only on the marginal utility associated with the additional private benefits of purchasing the non-GM product, scaled by the marginal utility of income. Recall that $\frac{\partial v}{\partial r_s}$ may still depend on the consumer's beliefs about the environmental or social impacts of the GM product, so WTP may still depend on b. A rational consumer will choose the non-GM product in labeling scenario s if and only if $\delta_s < \delta^*$.

Voter Behavior

Let $dV_{s,\,t}$ represent the change in approximate utility of moving from scenario s to scenario t. A utility-maximizing voter will support a change in regulation from s to t if and only if $dV_{s,\,t} > 0$.[13] Thus the probability that an individual votes in favor of the new regulation is simply $\Pr(dV_{s,\,t} > 0)$. We first compare voluntary labeling ($s = 1$) to no labeling ($s = 0$), separately for those with WTP above and below the premium for the non-GM product under voluntary labeling. Substituting in the expression for WTP given by equation (8) and totally differentiating gives:

$$(9) \quad \boldsymbol{dV_{0,1}} \mid (\boldsymbol{\delta^* \leq \delta_1}) = \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b_s}}(\boldsymbol{b_1} - \boldsymbol{b_0}) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{f_s}}(\boldsymbol{f_1} - \boldsymbol{f_0})$$

$$(10) \quad \boldsymbol{dV_{0,1}} \mid (\boldsymbol{\delta^* > \delta_1}) = \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p_s}}(\boldsymbol{\delta_1} - \boldsymbol{\delta^*}) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b_s}}(\boldsymbol{b_1} - \boldsymbol{b_0}) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{f_s}}(\boldsymbol{f_1} - \boldsymbol{f_0})$$

Equations (9) and (10) are unambiguously positive so all individuals would be in favor of voluntary labeling. Intuitively those with δ^* less than the premium for the non-GM product can buy the conventional good at the original price but still benefit from greater freedom of choice and any public benefits due to other consumers switching. Those with δ^* greater than the premium choose to buy the non-GM product because it increases their utility, by definition. We therefore use voluntary labeling as our reference or baseline scenario.[14]

To compare voluntary labeling ($s = 1$) to mandatory labeling ($s = 2$), we now must consider three types of individuals: those with $\delta^* \leq \delta_2$ who choose the GM product in both scenarios, those with $\delta_2 < \delta^* \leq \delta_1$ who switch from the GM to the non-GM product as labeling moves from voluntary to mandatory, and those with $\delta^* > \delta_1$ who choose the non-GM product in both scenarios. Again, substituting in our expression for WTP:

[13] We recognize that voting decisions will also be subject to imperfect information—voters may not invest in obtaining information about their choices because doing so is costly (Downs 1957). We also do not model the decision to vote in the first place, which limits our ability to test the notion of expressive voting, whereby individuals are more likely to vote when they care more intensely about the issues at stake (Brennan and Hamlin 2007).

[14] The current US market is characterized by voluntary labeling of non-GM foods. It is worth noting though that voluntary labeling is indeed a regulatory choice distinct from a no-labeling scenario. For example, some states had previously attempted to ban voluntary labels on milk products indicating that the milk came from cows not treated with recombinant bovine growth hormone, with manufacturers arguing that voluntary labels misled consumers.

$$(11)\quad dV_{1,2} \mid \left(\delta^* \le \delta_2\right) = \frac{\partial v}{\partial p_s}\Delta_2 + \frac{\partial v}{\partial b_s}(b_2 - b_1)$$

$$(12)\quad dV_{1,2} \mid \left(\delta_2 < \delta^* \le \delta_1\right) = \frac{\partial v}{\partial p_s}\left(\Delta_2 + \delta_2 - \delta^*\right) + \frac{\partial v}{\partial b_s}(b_2 - b_1)$$

$$(13)\quad dV_{1,2} \mid \left(\delta_1 < \delta^*\right) = \frac{\partial v}{\partial p_s}(\Delta_2 + \delta_2 - \delta_1) + \frac{\partial v}{\partial b_s}(b_2 - b_1)$$

Equation (11) suggests that among individuals with zero or low WTP (less than the premium for the non-GM product under mandatory labeling), a voter is more likely to favor mandatory labeling if she has a low marginal utility of income and perceives larger public benefits associated with the GM product. In contrast, equation (12) suggests that for individuals with moderate WTP (in the range of the premium for the non-GM product under voluntary and mandatory labeling), the effect of income may be positive or negative but is likely to be small as it depends on the difference between WTP and the price increase they face. Last, equation (13) shows that all those with high WTP (greater than the premium for the non-GM product under voluntary labeling) benefit from mandatory labeling (because $\delta_1 > \Delta_2 + \delta_2$) but that the probability of such an individual voting in favor is actually decreasing in income. Intuitively, if an individual is purchasing the non-GM product regardless of the regulatory scenario, she benefits more from a reduction in its price if she is less wealthy. Across all individuals, $\Pr(dV_{1,\ 2} > 0)$ is increasing in perceived public benefits but does not depend on private benefits after controlling for WTP.

To compare a ban to voluntary labeling, we only need consider two types of individuals: those with $\delta^* \le \delta_1$ who choose the GM product under voluntary labeling, and those with $\delta^* > \delta_1$ who choose the non-GM product under voluntary labeling (because voluntary labeling is unambiguously utility-increasing relative to no labeling for individuals that choose either product). Substituting in the expression for WTP as above:

$$(14)\quad dV_{1,3} \mid \left(\delta^* \le \delta_1\right) = \frac{\partial v}{\partial p_s}\left(\delta_3 - \delta^*\right) + \frac{\partial v}{\partial b_s}(b_3 - b_1) - \frac{\partial v}{\partial f_s}(f_1 - f_0)$$

$$(15)\quad dV_{1,3} \mid \left(\delta^* > \delta_1\right) = \frac{\partial v}{\partial p_s}(\delta_3 - \delta_1) + \frac{\partial v}{\partial b_s}(b_3 - b_1) - \frac{\partial v}{\partial f_s}(f_1 - f_0)$$

Akin to equation (12), equation (14) indicates that for individuals with low or moderate WTP, the sign of the effect of income on the probability of voting in favor of a ban depends on WTP itself. Again, perceived public benefits of the alternative have a positive effect but in this case it is counterbalanced by the disutility associated with loss of freedom to choose between the GM and non-GM products. Assuming that $\delta_3 < \delta_1$, given the reduction in search costs resulting from the mandatory ban, equation (15) suggests that all individuals with high WTP should prefer the ban to voluntary labeling regardless of their actual level of WTP, so long as they do not value freedom of choice more highly. Moreover, the probability of a vote in favor is again decreasing in income for those with high WTP, as less wealthy individuals benefit more in terms of utility from a reduction in the price of the alternative if they purchase it regardless of the regulatory scenario.

Note that because the above framework relies only on perceived public and private benefits, and not on actual benefits to health or the environment or society in general, we cannot draw any conclusions about the welfare implications of each regulatory scenario. Our aim is to identify the role of the factors underlying consumer and voter decisions. In the case of GM food, individuals make decisions based on the health and environmental risks, and damages they perceive to be associated with the technology, but any actual health and environmental effects associated with production or consumption of GM food are a separate matter.

Summary of Empirically Testable Hypotheses

In summary, the above framework based on the assumption of a consistent and utility-maximizing consumer-voter yields the following hypotheses:

i. WTP for the non-GM product is inversely proportional to the marginal utility of income and thus scales positively with income. WTP is increasing in perceived private and public benefits, although the latter is a second order effect.
ii. Assuming that voters will support mandatory labeling if doing so increases their

utility, in estimating the probability that a respondent votes in favor of mandatory labeling we are estimating $\Pr(dV_{1,2}) > 0$. Letting Y be the event that the individual votes in favor of mandatory labeling over voluntary labeling:

$$(16) \quad \boldsymbol{Pr}(\boldsymbol{Y}|\boldsymbol{\delta}^* \leq \boldsymbol{\delta}_2) = \boldsymbol{Pr}\left(\frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p}_s}\boldsymbol{\Delta}_2 + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b}_s}(\boldsymbol{b}_2 - \boldsymbol{b}_1)\right) \geq \boldsymbol{0}$$

$$(17) \quad \boldsymbol{Pr}(\boldsymbol{Y}|\boldsymbol{\delta}_2 < \boldsymbol{\delta}^* \leq \boldsymbol{\delta}_1) = \boldsymbol{Pr}\left(\frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p}_s}(\boldsymbol{\Delta}_2 + \boldsymbol{\delta}_2 - \boldsymbol{\delta}^*) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b}_s}(\boldsymbol{b}_2 - \boldsymbol{b}_1)\right) \geq \boldsymbol{0}$$

$$(18) \quad \boldsymbol{Pr}(\boldsymbol{Y}|\boldsymbol{\delta}_1 < \boldsymbol{\delta}^*) = \boldsymbol{Pr}\left(\frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p}_s}(\boldsymbol{\Delta}_2 + \boldsymbol{\delta}_2 - \boldsymbol{\delta}_1) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b}_s}(\boldsymbol{b}_2 - \boldsymbol{b}_1)\right) \geq \boldsymbol{0}$$

The probability of an individual voting in favor of mandatory labeling of GM food is increasing in income for those with low WTP and decreasing in income for those with high WTP. Greater perceived public benefits increase the probability of voting in favor across all groups, whereas perceived private benefits, as captured by WTP, are only relevant for individuals with WTP approximately equal to the price premium for the non-GM product.

iii. Similarly, letting X be the event that the individual votes in favor of a ban over voluntary labeling:

$$(19) \quad \boldsymbol{Pr}(\boldsymbol{X}|\boldsymbol{\delta}^* \leq \boldsymbol{\delta}_1) = \boldsymbol{Pr}(\frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p}_s}(\boldsymbol{\delta}_3 - \boldsymbol{\delta}^*) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b}_s}(\boldsymbol{b}_3 - \boldsymbol{b}_1) - \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{f}_s}(\boldsymbol{f}_1 - \boldsymbol{f}_0)) \geq \boldsymbol{0}$$

$$(20) \quad \boldsymbol{Pr}(\boldsymbol{X}|\boldsymbol{\delta}^* > \boldsymbol{\delta}_1) = \boldsymbol{Pr}\left(\frac{\partial \boldsymbol{v}}{\partial \boldsymbol{p}_s}(\boldsymbol{\delta}_3 - \boldsymbol{\delta}_1) + \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{b}_s}(\boldsymbol{b}_3 - \boldsymbol{b}_1) - \frac{\partial \boldsymbol{v}}{\partial \boldsymbol{f}_s}(\boldsymbol{f}_1 - \boldsymbol{f}_0)\right) \geq \boldsymbol{0}$$

The probability of an individual voting in favor of a ban on GM products is increasing in income for those with low or moderate WTP and decreasing in income for those with high WTP. Greater perceived public benefits increase the probability of voting in favor across all groups, Although greater option value decreases the probability. Perceived private benefits, as captured by WTP, are only relevant for individuals with low or moderate WTP.

Survey and Data

Because individual-level data containing actual contemporaneous voter and consumer choices cannot be obtained, and a revealed preference analysis is thus infeasible, we rely on survey data to test the above hypotheses. The backdrop to our survey is a 2012 California ballot initiative (Proposition 37) proposing mandatory labeling of GM food. Had it passed, the initiative would have required all food sold in California containing GM ingredients above a certain threshold tolerance to be labeled as such, excluding meat, dairy, and food sold in restaurants. Although eventually rejected by a slim margin, prior polls had shown voters to be strongly in favor.

Figure 1 plots cumulative campaign spending and poll results over the period leading up to the election. It shows a clear shift in the majority opinion following a large increase in spending by the coalition against mandatory labeling. The campaign against the proposition largely concentrated their efforts on communicating the costs that consumers would likely incur if mandatory labeling were implemented (McFadden and Lusk 2013). The dramatic shift in public opinion over the course of the campaign suggests that the campaign increased public awareness of the issue of GM food. The debate surrounding the proposition also served to increase salience and respondent experience with the choices presented during our survey.

It is also important to note that the aim of this study is not to accurately estimate average WTP or the proposition's approval rating but rather to compare consumer and voter decisions. Bias associated with the use of a survey is therefore not a concern unless it affects consumption and voting decisions differentially. Nonetheless, our estimates for WTP fall within the range found in the literature, which includes a number of experimental and market-based revealed preference studies. Our implied approval rating of approximately 60% in favor of Proposition 37 was also relatively close to estimates provided by pre-election polls at the time we conducted the survey, as shown in figure 1. These consistencies lend support to the external validity of our survey. Differences between our estimates and those based on revealed preference may be attributed to the fact that our sample is not representative of the population as a whole, and likely not the population of voters, as discussed in the following section.

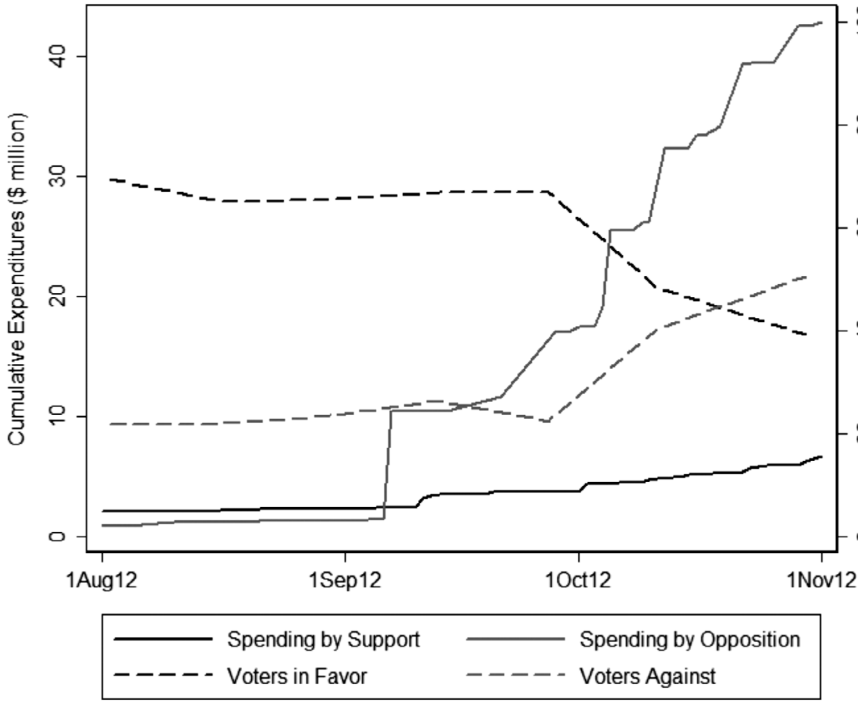

Figure 1. Proposition 37 cumulative campaign spending and pre-election poll results.

Sources: California Business Roundtable and Pepperdine University School of Public Policy Initiative Survey; CAL-ACCESS Campaign Finance and Lobbying Activity.

Survey Instrument

Our survey was administered online to a stratified sample of 715 California voting-age residents ten days prior to the election in which Proposition 37 was on the ballot. The panel was constructed from surveymonkey.com's preregistered database of respondents who complete web-based surveys in exchange for small rewards (a $0.50 charitable donation and entry into a gift card lottery). Although web-based surveying is a comparatively new mode for collecting stated preference data, there is evidence supporting its validity relative to phone and face-to-face survey modes (Lindhjem and Navrud 2011). Although we attempted to obtain a sample that reasonably represented the CA voting-age population, we were limited by the pool of potential respondents. Our sample therefore tends to be older, more educated, wealthier, and less racially diverse than the CA population overall, although somewhat more similar in demographic distribution to the population of likely voters.[15] We nonetheless have enough variation in our sample to control for these characteristics in our analyses. Additionally, we have included a re-creation of the WTP and voting questions in the Appendix, and the full raw dataset, including the exact phrasing of all questions, has been made publicly available online.

To elicit WTP for a GM-free product under a mandatory labeling scenario, we presented respondents with simultaneous side-by-side images of otherwise identical nutrition and ingredient labels for a popular breakfast cereal, only one of which carried the statement "MAY CONTAIN GENETICALLY ENGINEERED INGREDIENTS."[16] Respondents provided their maximum WTP for the unlabeled (non-GM) version of the product by selecting an interval from a simple payment card with eight choices covering the range from $0 to over $2.00, to be paid in addition

[15] See "Just the Facts: California's Likely Voters", Public Policy Institute of California, August 2017 at http://www.ppic.org/wp-content/uploads/JTF_LikelyVotersJTF.pdf

[16] Under a mandatory labeling scheme, GM products would be affirmatively labeled as such. Non-GM products would be labeled as not containing GM ingredients under a voluntary labeling scheme. Our instrument is therefore reflective of a mandatory labeling scheme, as proposed on the ballot. Surveys similar to ours often provide respondents with the additional explanation that a product being unlabeled implies its GM-free status, but we omitted such a statement to more realistically represent the actual choice scenario, where grocery store shoppers would be left to make this inference themselves.

to the $1.99 price of the labeled product. Respondents were also allowed to opt out by stating that they would purchase neither the labeled nor unlabeled product. To mitigate hypothetical bias, we included a statement encouraging respondents to remember to consider their actual household budget when making their choice. Although the literature indicates mixed results with regard to the efficacy of a soft "cheap talk" script along these lines, a number of studies conclude that the inclusion of such statements can narrow the gap between hypothetical and actual WTP (Carlsson, Frykblom, and Lagerkvist 2005).

Although a preferable value for the purpose of this study would be an estimate of consumers' willingness to pay for GM-free food overall, we posed the question in reference to a single product to better approximate an actual choice scenario. Obtaining estimates of overall WTP is further complicated by the fact that WTP for non-GM products varies depending on the type of product in question (Rousu et al. 2007) and the particular characteristics conferred by genetic modification (Colson and Huffman 2011).

Following the WTP question, we asked respondents how they intended to vote on Proposition 37 and how they would vote in favor of a ban on GM products. For the question regarding the mandatory labeling proposition, we included the description of the proposition that appeared on the actual ballot when citizens went to vote. This is in contrast to standard CV methodology, where provision of background information is an important component of survey design left to the researchers' subjective judgment (Vossler and Kerkvliet 2003; Johnston 2006). Additionally, as noted above, most respondents were already aware of GM food and the ballot initiative due to the extent of recent media campaigning (see figure 1) and, therefore, had time to form opinions on the issue. Salience and respondent experience were thus less of a concern than in a typical contingent valuation setting.

In addition to standard demographic data, we also collected information on respondent's knowledge and perceptions of GM food. We asked for a self-reported measure of how much they knew about the use of genetic engineering in food production on a scale of 1 (none) to 5 (very well-informed), similar to the subjective measure of prior information in Huffman et al. (2007). As a more objective measure of GM knowledge, respondents were also asked about the percentage of packaged grocery store food they thought contained GM ingredients. To proxy for perceived private and public benefits of non-GM food, respondents were also asked to rate how safe they thought GM food was for the environment on a scale of 1 (very unsafe) to 5 (very safe), with options to state that they were unsure or did not know, and likewise how safe they thought consumption of GM food was for health. Following these questions, respondents were provided with a description of the "Non-GMO Project Verified" label and asked if they have intentionally purchased items that display the label or if they plan to do so in future.

Summary Statistics

Of our 715 respondents, 7% opted out of the WTP question and 55% reported zero WTP for the GM-free product. Using the midpoints of the WTP ranges in our data, mean WTP was $0.35, or 18% of the base price. This mean estimate falls within the wide range of estimates in the literature, toward the more conservative end of the spectrum. Twenty-nine percent of respondents scored themselves one or two out of five in terms of how much they knew about genetically engineered food, whereas 42% scored themselves four or five out of 5. However, 68% believed that the percentage of non-organic packaged food items at a regular U.S. grocery store that contain GM ingredients was between 0% and 60%. The actual proportion is over 70% (Grocery Manufacturer's Association 2013). Thirty-three percent of respondents believed GM foods to be fairly or very unsafe for consumption, whereas 45% believed them to be fairly or very safe. The remainder were uncertain or did not know. Forty-three percent believed that growing GM crops was unsafe for the environment, whereas 36% believed it to be safe.

Table 1 describes and counts the number of survey respondents falling within each categorization defined by WTP, support for mandatory labeling, and support for a ban. We consider three categories of WTP to coarsely approximate the division suggested by our conceptual model, relative to the price premium for the non-GM product. Kalaitzandonakes, Lusk, and Magnier (2018) estimate

Table 1. Mean Respondent Characteristics, by Voting Choices and WTP

WTP	N	Age (Yrs)	Education (Yrs)	Income ($000)	Passed test (%)	Safe to consume (Belief Scale 1 to 5)	Safe for environment (Belief Scale 1 to 5)
No label or ban							
Low	213	54	16	53	28%	4.3	4.2
Mid	24	53	16	48	21%	3.8	3.5
High	8	51	17	43	13%	4.3	4.0
All	**245**	**54**	**16**	**52**	**27%**	**4.3**	**4.1**
Label only							
Low	69	48	16	45	32%	3.9	3.6
Mid	29	48	16	55	41%	3.4	3.1
High	27	42	16	50	30%	3.3	2.7
All	**125**	**47**	**16**	**48**	**34%**	**3.6**	**3.3**
Ban only							
Low	17	51	15	43	18%	2.6	3.3
Mid	2	55	15	44	50%	4.0	3.0
High	5	40	15	51	0%	2.0	1.7
All	**24**	**49**	**15**	**45**	**17%**	**2.6**	**2.9**
Label and ban							
Low	97	50	15	43	38%	2.2	1.9
Mid	84	44	15	37	30%	2.5	1.9
High	87	42	16	43	44%	2.2	1.8
All	**268**	**46**	**15**	**41**	**37%**	**2.3**	**1.9**
Opted out of WTP	53	48	16	53	36%	2.1	1.9
All	**715**	**49**	**16**	**47**	**32%**	**3.2**	**2.9**

Notes: "Passed test %" is the percentage of respondents who correctly believed that over 60% of packaged non-organic food sold in grocery stores contained any GM ingredients; "Safe to consume" is the mean value respondents gave for how safe they believe GM food is for human health (1 for "very unsafe" to 5 for "very safe"). "Safe for environment" is the mean value respondents gave for how safe they believe GM food is for the environment (1 for "very unsafe" to 5 for "very safe").

the average premium for products certified to be GM-free across various food product categories using a hedonic approach. They estimate that, under the voluntary labeling scheme currently in place in the U.S., the average price premium associated with non-GM certified labeling for breakfast cereals is approximately 26%. The price premium under voluntary labeling represents the upper bound of the moderate WTP category, so we define low WTP ($0), moderate ($0.01 to $0.50), and high (more than $0.50).[17] Overall, the patterns observed make intuitive sense. Respondents against both banning and labeling tend to be older, consistent with the previous literature discussed in the introduction. The percentage failing our objective test about GM food decreases as we move to respondents choosing stricter regulation. Across all respondent types, individuals tend to be slightly more concerned about the environmental impacts of growing genetically engineered crops than about the health impacts of consuming GM food (a lower safety score indicates greater concern). Respondents favoring stricter regulation also appear more concerned about both environmental and consumer safety.

The largest respondent category is zero WTP and against both banning and mandatory labeling. These individuals tend to be older and wealthier than the full sample and very confident in the safety of GM foods. A significant proportion of respondents with zero WTP are willing to require labeling but are not in favor of a ban. They tend to be younger and less wealthy than those against both policies with zero WTP and to be more concerned about both health and environmental safety. Those in favor of both banning and mandatory labeling are approximately equally likely to have zero, moderate, or high WTP. Regardless of WTP, these respondents

[17] This categorization is approximate at best, as the price premium is variable and imprecisely known to consumers, but our subsequent results are not sensitive to the particular categorization.

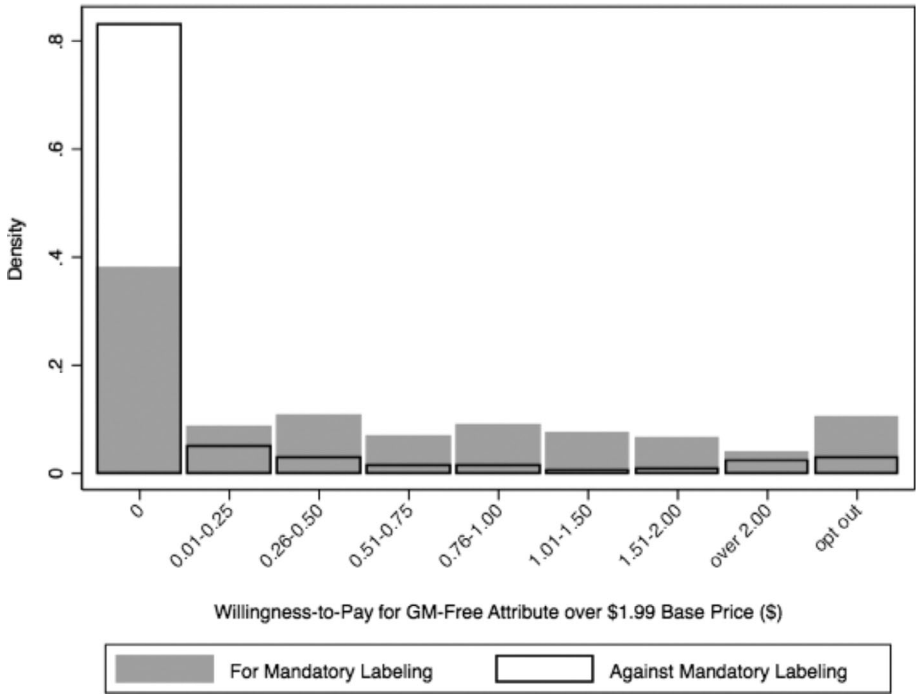

Figure 2. Willingness-to-pay by willingness to vote in favor of mandatory labeling.

Note: Histogram shows frequency of willingness to pay responses, by mandatory labeling voting choice.

unsurprisingly tend to report being very concerned about the health and environmental safety of GM food. The twenty-four respondents in favor of a ban but not mandatory labeling are somewhat anomalous, because intuitively labeling is a more moderate regulatory option than a ban. Given the small size of this group, their counterintuitive choice patterns may also be due to idiosyncratic aversion toward Proposition 37 or mandatory labeling as a regulatory option, or simply a sign of inattention.[18]

Figure 2 presents a histogram of WTP by willingness to vote in favor of mandatory labeling, showing that the distribution of WTP is indeed much more concentrated at 0 among respondents who would vote against the ban than among those who would vote in favor. Intuitively those who are not opposed to the technology would be neither willing to pay to avoid it nor willing to vote against it. Figure 3 presents the frequency of household income per household adult by willingness to vote for mandatory labeling. The distribution of income is more right skewed among individuals who would vote in favor than among those who would vote against. Low-income individuals thus appear more likely to vote for regulation than higher income individuals. We explore this finding in our analysis below. Equivalent histograms examining voter support for a ban instead of mandatory labeling are qualitatively very similar.

Empirical Analysis

Because we elicited WTP using a payment card format, our responses are interval censored, and we use interval regression to estimate WTP for the GM-free product that accounts for censoring at $0 and $2 as well as the interval structure of the data. Recall that equation (8) of our conceptual framework suggests that WTP depends only on the marginal utility associated with the additional private benefits of purchasing the benign good, scaled by the marginal utility of income. If concerns

[18] A sign of inattention is the time in which it took a respondent to complete the survey. We find that our results are qualitatively robust to the exclusion of responses completed in fewer than two or five minutes. Results presented throughout the article exclude responses completed in less than two minutes (N = 24).

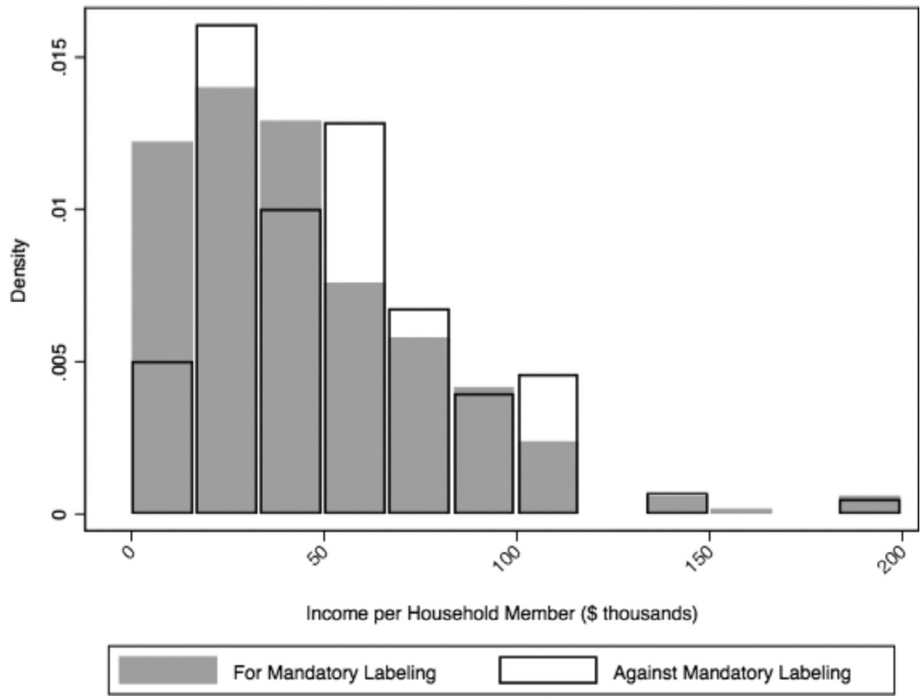

Figure 3. Household income per person by willingness to vote in favor of mandatory Labeling.

Note: Histogram shows distribution of household income divided by number of household members, by mandatory labeling voting choice.

about the environment enter into the WTP decision, this would indicate that our respondents either believe in the efficacy of green consumption or that they gain satisfaction from making purchases they believe to be ethical or socially responsible.

The estimation results for the full sample are presented in the first column of table 2. Our coefficients on basic demographic variables are consistent with the prior literature on WTP for GM-free food. Low income is defined as household income below the 25th percentile in our sample and high income as income above the 75th percentile, although all of our results are insensitive to changing these cutoff values. The coefficient on the low-income indicator is negative, as would be expected given (8), but statistically insignificant. The coefficient on high income is also unsurprisingly small in magnitude and insignificant, given that income is only important up to the point that it might prevent a consumer from purchasing the non-GM product when she has a preference for it. Non-GM food is not a luxury good and entails a relatively small expense. Correct knowledge that a majority of packaged non-organic grocery items contain GM ingredients, the coefficient on the "Test Pass" indicator, significantly decreases mean WTP by $0.11.

The indicator variables "Health Safe" and "Health Unsafe" represent consumption safety ratings 4 to 5 out of 5 and 1 to 2 out of 5 respectively, and proxy for perceived private benefits of consuming GM-free food. Similarly, "Environment Safe" and "Environment Unsafe" proxy for perceived public benefits. The coefficients on these variables have the expected signs but only "Environment Unsafe" is statistically significantly related to WTP. Moreover, environmental concern increases average willingness to pay by $0.25, whereas concern about health impacts increases average willingness to pay by only $0.10 relative to the omitted category of respondents who were ambivalent about the safety of GM or stated that they did not know. Interestingly, among our sample the belief that GM food is unsafe for the environment is a more important determinant of WTP than the belief that GM food is unsafe to consume. Also note that the coefficients on the two "unsafe" variables are larger in magnitude and more strongly significant than those on

Table 2. Determinants of Willingness to Pay for Non-GM Product

	WTP (1)	P(WTP > 0) (2)	WTP|WTP > 0 (3)
Low Income	−7.39	−0.00	−13.27
	(5.83)	(0.15)	(10.02)
High Income	−1.94	−0.06	−1.07
	(4.87)	(0.13)	(10.08)
Health Safe	−7.54	−0.34**	0.87
	(6.72)	(0.17)	(12.56)
Health Unsafe	10.29	−0.10	25.61**
	(8.22)	(0.17)	(10.84)
Environment Safe	−6.62	−0.42**	9.45
	(6.08)	(0.18)	(14.27)
Environment Unsafe	24.85***	0.70***	6.15
	(7.27)	(0.16)	(10.28)
Self-Rep Knowledge	2.06	0.04	2.46
	(1.78)	(0.05)	(3.48)
Test Pass	−11.08**	−0.19	−15.42*
	(4.56)	(0.12)	(8.77)
Age	−0.89***	−0.02***	−0.95***
	(0.15)	(0.00)	(0.28)
Education	2.27*	0.06*	3.10
	(1.32)	(0.03)	(2.53)
Male	−3.33	0.01	−9.01
	(4.24)	(0.11)	(8.06)
Constant	37.32*	−0.21	71.73*
	(21.15)	(0.48)	(39.32)
Observations	658	658	265

Notes: Columns 1 and 3 present results from interval regressions of WTP, for the full sample and for respondents with non-zero WTP respectively. Column 2 presents results from probit regression of an indicator for WTP greater than zero. Heteroscedasticity-robust standard errors in parentheses. Asterisks *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

the two "safe" variables. In terms of WTP, respondents who were uncertain about GM safety thus tend to behave more similarly to respondents who believe GM food to be quite or very safe.

Given the large proportion of zero WTP responses, we also run a hurdle model specification where we first estimate the probability that a respondent reports WTP greater than zero and then estimate the level of WTP conditional on such participation. We use a probit for the former, estimating the probability that the expression for δ^* given in equation (8) is greater than zero (column 2). Results are qualitatively robust to a linear probability specification estimated via ordinary least squares. For the latter we again use interval-censored regression to estimate $\delta^* \mid \delta^* > 0$ (column 3). Here our results are unchanged by inclusion of the inverse Mills ratio to account for endogeneity.

Our results indicate that, to some extent, different factors do indeed drive the decision to purchase GM-free food and the decision regarding how high a premium to pay. Intuitively, the coefficients on the two income variables are close to zero and insignificant in the participation regression. The coefficient on low income is negative and large in the conditional WTP regression, although imprecisely estimated. These results suggest that income does not affect whether a consumer prefers to purchase GM-free food or not but does determine how much she is able to spend.

Interestingly, a respondent who believes GM food to be safe for consumption is significantly less likely to buy the non-GM product at all, but conditional on participation, belief that GM food is unsafe to consume significantly increases WTP by an average of $0.26. A consumer is willing to spend much more to avoid GM food if she believes it to be associated with health risks. Conversely, belief that GM food is unsafe for the environment significantly increases the probability of participation but not average conditional WTP. In this context, environmental concerns therefore tend to encourage respondents to "vote" with their

Table 3. Determinants of Probability of Voting in Favor of Mandatory Labeling

	Full Sample (1)	Low WTP (2)	Mid WTP (3)	High WTP (4)
WTP	0.015***			
	(0.005)			
Low Income	0.499***	0.592***	0.390	0.568
	(0.165)	(0.216)	(0.343)	(0.423)
High Income	0.069	0.010	0.004	0.286
	(0.122)	(0.167)	(0.344)	(0.404)
Health Safe		−0.196	−0.892**	−0.069
		(0.238)	(0.378)	(0.389)
Health Unsafe		0.499*	0.567	0.563
		(0.303)	(0.539)	(0.454)
Environment Safe	−0.709**	−0.879***	−0.287	−1.472***
	(0.345)	(0.222)	(0.453)	(0.566)
Environment Unsafe	0.399	0.788***	0.572	−0.325
	(0.410)	(0.290)	(0.388)	(0.484)
Self-Rep Knowledge	−0.009	−0.029	−0.024	0.431**
	(0.051)	(0.064)	(0.139)	(0.200)
Test Pass	0.351***	0.202	0.502	0.993 **
	(0.117)	(0.166)	(0.395)	(0.459)
Age	0.001	−0.009	−0.018	0.010
	(0.007)	(0.006)	(0.011)	(0.013)
Education	0.004	0.057	0.088	−0.040
	(0.032)	(0.040)	(0.077)	(0.100)
Male	−0.057	−0.091	−0.081	−0.095
	(0.127)	(0.157)	(0.303)	(0.369)
Constant	−0.450	−0.441	0.275	0.080
	(0.578)	(0.654)	(1.111)	(1.540)
Observations	658	393	138	127

Notes: All columns estimated via probit. Predicted WTP from regressions summarized above in table 2 are used as instruments for WTP in column (1). Heteroscedasticity-robust standard errors in parentheses; Asterisks *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

product choice, whereas private good health concerns tend to impel respondents to actually increase spending.

For comparison between the factors underlying consumer and voter choices, table 3 first presents estimation results for the probability of voting in favor of the mandatory labeling proposition across our full sample. As with the WTP participation regression, we estimate a probit model but now include WTP as a covariate, consistent with our theoretical framework. Following Hamilton, Sunding, and Zilberman (2003), to address endogeneity we use predicted values of WTP generated by the hurdle model summarized in table 2 above to instrument for observed WTP. As suggested by equations (11) to (15), perceived private benefits do not enter into the voting decision other than through WTP. So, we omit private benefits (the "Health Safe" and "Health Unsafe" variables) from the full-sample voting estimation equation, ensuring that the exclusion restriction for our instrument is satisfied.

The hypotheses summarized in equations (16)–(18) suggest that we should ideally split our sample into three groups depending on the magnitudes of WTP relative to the premia for GM-free food under voluntary and mandatory labeling. These premia are imprecisely known but, as in table 1, we divide our sample into respondents with zero willingness to pay, which will capture a greater proportion of individuals represented by equation (16), those with moderate willingness to pay, which will capture a greater proportion of individuals represented by equation (17), and those with high WTP to capture respondents represented by equation (18).[19] As described above, the cut-off points for the categories are defined on the basis of a prior

[19] Note that our conceptual development indicates that WTP is a continuous representation of an individual's preferences, and voting decisions depend on WTP and other external factors. Although the voting decisions are endogenous, and the same unobservables likely influence WTP and support for regulation, there is not a simultaneous relationship between WTP and willingness to vote.

estimate of the price premium for non-GM breakfast cereals under voluntary labeling. Again, our results are not sensitive to changing the boundaries for these categorizations.

The results for each of these three specifications are summarized in columns (2), (3), and (4) of table 3, respectively. Consistent with our hypotheses, WTP is a strongly significant predictor of willingness to support mandatory labeling. The coefficients on the demographic variables are fairly comparable to those in the WTP participation regression, although low income significantly increases the probability of voting in favor by 50%. The coefficients on the environmental safety indicators are also comparable, although here the magnitude is somewhat larger and more strongly significant for the "safe" variable than the "unsafe" variable. The omitted category, those who are ambivalent or uncertain about the safety of GM food, thus tend to behave more closely to those who think GM food is unsafe. This is the reverse of the WTP results and suggests that individuals may be more averse to GM food when acting as voters with regard to mandatory labeling than when acting as consumers. Also, in contrast to WTP, correct knowledge that a majority of packaged non-organic grocery items contain GM ingredients significantly increases the probability of voting support for mandatory labeling.

Sample selection bias is not a concern, as we are interested in the determinants of the voting decision conditional on WTP in order to compare across different WTP categories not in generalizing our estimates to the population. Coefficients on demographic and knowledge-related variables are qualitatively similar to those estimated on the full sample of respondents. For income, equation (16) suggests a positive relationship with the probability of supporting the mandatory labeling proposition for low WTP respondents, whereas equation (18) suggests a negative relationship among high WTP respondents. Column (4) reports a positive coefficient on the low-income indicator among the latter as expected, although it is insignificant, and a coefficient close to zero on the high-income indicator. For low WTP respondents, however, we expect a negative coefficient on low-income but observe a large positive coefficient significant at the 1% level. The probability of a low-income respondent with zero WTP voting in favor of mandatory labeling is almost 60% higher than that of a wealthier respondent. This result suggests that low-income voters may choose to exercise their power as voters where they could not as consumers, even if this decision is not consistent with utility maximization.

Because there is not enough variation in our WTP variable to include it as a covariate in each of the subsamples, we instead include the consumption safety indicator variable directly to reflect perceived private benefits of the non-GM product. Among the low WTP subsample, only the environmental safety indicators are significant at the 5% level, and their coefficients are larger in magnitude than those on the consumption safety indicators. This finding is consistent with equation (16), which suggests that individuals with low WTP should be unconcerned with the private benefits in deciding their vote on mandatory labeling because they will not purchase GM-free food, and therefore will not receive those private benefits, even if the proposition passes. In contrast, among those with moderate WTP (represented by equation [17]), perceived consumer safety is a significant determinant of the voting decision, because δ^* enters into the expression for the change in utility. Among the high WTP subsample, none of the safety indicators are significant, and three out of four of the coefficients are close to zero, again indicating that respondents with high WTP favor the regulation regardless of their other characteristics. However, small sample size may be problematic here, because among those with high WTP, only 13 of 127 respondents would vote against labeling.

Table 4 presents equivalent estimation results for the vote to ban. Again, we assume that the probability of voting in favor of a ban is equal to the probability that an individual's utility increases under a ban. Thus, for the vote to ban GM food, we estimate Pr $(dV_{1,3}) > 0$ by coarsely dividing our sample into respondents with zero to moderate WTP, representing a larger share of individuals captured by equation (19), and those with high WTP, representing mostly individuals described by equation (20).

Here, years of education is significantly negatively correlated with voting support, whereas age is significantly positively correlated. Comparing the predicted determinants of $dV_{1,2}$ to those of δ^* and $dV_{1,3}$, this finding perhaps suggests that the marginal utility of freedom of choice is increasing in education and decreasing in age. As with mandatory labeling, voting support for a ban is increasing

Table 4. Determinants of Probability of Voting in Favor of a Ban on GM Food

	Full sample (1)	Low to mid WTP (2)	High WTP (3)
WTP	0.017***		
	(0.002)		
Low Income	0.336**	0.376**	0.409
	(0.137)	(0.190)	(0.360)
High Income	0.051	−0.029	0.212
	(0.109)	(0.177)	(0.304)
Health Safe		−0.482**	−0.622*
		(0.209)	(0.373)
Health Unsafe		0.724***	0.644*
		(0.233)	(0.352)
Environment Safe	−0.509*	−1.313***	−0.393
	(0.271)	(0.249)	(0.458)
Environment Unsafe	0.069	0.870***	0.505
	(0.274)	(0.197)	(0.378)
Self-Rep Knowledge	0.005	0.114*	−0.009
	(0.043)	(0.062)	(0.124)
Test Pass	0.229**	0.033	0.270
	(0.103)	(0.171)	(0.315)
Age	0.014***	−0.007	0.010
	(0.004)	(0.005)	(0.011)
Education	−0.089***	−0.094**	−0.090
	(0.034)	(0.040)	(0.084)
Male	−0.079	−0.241	−0.243
	(0.109)	(0.151)	(0.287)
Constant	−0.054	1.248**	1.125
	(0.531)	(0.624)	(1.362)
Observations	658	531	127

Notes: All columns estimated via probit. Predicted WTP from regressions summarized above in table 2 are used as instruments for WTP in column (1). Heteroscedasticity-robust standard errors in parentheses; Asterisks *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

in WTP and higher on average among low-income respondents. The coefficients on the variables regarding the environmental safety of GM food have the expected signs, with the magnitude again substantially larger for the "safe" indicator. Uncertain voters tend to behave more similarly to voters who perceive GM foods to be unsafe. Voters therefore appear to express more aversion to GM food than consumers even in the case of a much more stringent regulatory option.

Additionally, the expected relationship to income is unclear among the low and moderate WTP group, although more likely to be positive given the dominance of respondents with zero WTP. Income is expected to be negatively associated with the probability of voting in favor of a ban among the high WTP group. For high WTP respondents we find no statistically significant relationship between income and the probability of a vote in favor, although the estimated signs are consistent with the equation (20). However, we again find a positive and significant effect of low income among low or moderate WTP respondents. As with the mandatory labeling decision, this observation suggests that the cost burden of a ban may not be adequately acknowledged by voters and that low-income individuals may tend to over-vote relative to their actual WTP as a result.

Both environmental safety and consumption safety are important factors in the decision to vote in favor of a ban among low or moderate WTP respondents, as equation (19) suggests because both public benefits and private benefits, via their role in δ^*, enter into the expression for the associated change in utility. Interestingly though, we find that health concerns tend to be the more important determinant among our high WTP subsample, in contrast to the predictions of equation (20). This result may indicate that concerns about the health risks associated with GM food could constitute a perceived public benefit as well as a perceived private benefit. Those who feel GM foods are unsafe for consumption may be concerned about health effects for all consumers.

Conclusion

A production technology is controversial when there is disagreement regarding its associated environmental or social externalities, and/or its private consumption risks. Individuals in initiative and referendum states can and do respond to such technologies as voters deciding to support regulation and as consumers choosing to pay a premium for an alternative that avoids the technology. In this article, we formalize the relationship between WTP and willingness to vote for different forms of regulation of GM food. Assuming a very general utility function, our model suggests that WTP is an important factor in the probability of voting in favor of regulation but that its effect is not smooth. Instead, WTP divides the population of potential voters into subgroups for whom the other factors that determine changes in utility between regulatory options are of different relative importance, most notably income and the perceived private and public benefits associated with non-GM products.

The foundation for our conceptual models is an expanded utilitarian framework, where we account for consumers' preferences with respect to prices, perceived health and environmental amenities, and freedom of choice. Our utilitarian approach is useful because it allows us to assess the consistency of choices made by individuals based on their characteristics and perceptions in an empirical setting. We recognize, however, that consumer voting decisions will also be influenced by imperfect information—individuals may not invest in obtaining information about their voting outcomes because it is costly (Downs 1957). Another limitation of our model is that we do not account for the decision to vote in the first instance, which limits our ability to test the notion of expressive voting (Brennan and Hamlin 2007). Although we compare three potential policies, our analysis does not consider the social welfare implications of each. As Caplan (2011) suggests, rational voting may result in socially suboptimal outcomes. Indeed, in the case of GM food, there are studies that argue that many of these policies (e.g. bans in Europe) may be far from optimal (Bennett et al. 2013).

The California ballot proposition on mandatory labeling of GM food provided an ideal opportunity to examine both consumer and voter behavior with real-world context in response to the same topical and controversial technology. Among our survey sample, respondents are overall more concerned about the environmental safety of genetically engineered crops than they are about the safety of GM food for human health. We find that WTP for GM-free food indeed depends on both environmental and health concerns, but that the former has a greater impact. However, we also find that perceived environmental risks encourage consumers to "vote" by choosing GM-free food, whereas perceived health risks increase the actual level of WTP.

Our analysis also suggests some potentially broader patterns regarding the differentiated impacts of individual characteristics on consumer and voter behavior. First, we find that knowledge of the existing extent of GM technology in the food supply decreases private WTP but increases support for regulation. Second, we find that those who are ambivalent or uncertain about the environmental safety of GM food will express greater aversion to GM food as voters than as consumers. Whereas uncertain consumers' WTP tends to be more similar to WTP among those who believe GM food is safe, uncertain voters tend to support regulation as though they believed GM food to be unsafe. In relative terms, these individuals may tend to "over-vote" if their private WTP is used as the metric for utility.

We also find only a weak relationship between income and WTP, whereas willingness to vote for regulation is positively associated with low income among respondents for whom such a relationship is not predicted by our utility maximization framework. Our model suggests that among respondents with low WTP, the probability of voting in favor of regulation will decrease with the marginal utility of income, but we find evidence of the opposite effect. Individuals in the low WTP group with lower income tend to vote more in favor of regulation. Low-income individuals are perhaps more likely to vote in favor of regulation because they are more constrained in their ability to pay the premium for GM-free food or because the implicit costs to consumers associated with regulation are less apparent in the voting context. Further analysis is needed to assess whether this tendency exists with regard to other controversial technologies, and to understand the possible distributional consequences.

Supplementary Material

Supplementary material is available at *American Journal of Agricultural Economics* online.

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Appendix

WTP and Voting Questions As Included in Survey

Box B sells for $1.99 at your regular supermarket or grocery store. How much extra would you be willing to pay for box A? (Please consider your household budget and expenses, and try to answer as you would if you were actually making the decision while out food shopping.)

- I would not pay any extra for Box A
- $0.01 to $0.25
- $0.26 to $0.50
- $0.51 to $0.75
- $0.76 to $1.00
- $1.01 to $1.50
- $1.51 to $2.00
- More than $2.00
- I would not buy either box

Would you vote in favor of a ban on the use of genetic engineering in food production?

- Yes
- No

Proposition 37 of the 2012 California Ballot would require all raw and processed foods containing genetically engineered ingredients to be labeled, except for organic food, animal products, and food sold in restaurants. Would you vote in favor of mandatory labeling of genetically engineered foods?

- Yes
- No

Box A

Ingredients: Whole Grain Corn, Whole Grain Oats, Sugar, Whole Grain Barley, Whole Grain Wheat, Whole Grain Rice, Corn Starch, Salt, Canola and/or Rice Bran Oil, Tripotassium Phosphate, Color Added. Vitamin E (mixed tocopherols) Added to Preserve Freshness. Vitamins and Minerals: Calcium Carbonate, Zinc and Iron (mineral nutrients), Vitamin C (sodium ascorbate), A B Vitamin (niacinamide), Vitamin B_6 (pyridoxine hydrochloride), Vitamin B_2 (riboflavin), Vitamin B_1 (thiamin mononitrate), Vitamin A (palmitate) A B Vitamin (folic acid), Vitamin B_{12} Vitamin D_3.
CONTAINS WHEAT INGREDIENTS.

This package is sold by weight, not by volume. You can be assured of proper weight even though some setting of contents normally occurs during shipment and handling.
F3851607538 SSG 3917380538

Box B

Ingredients: Whole Grain Corn, Whole Grain Oats, Sugar, Whole Grain Barley, Whole Grain Wheat, Whole Grain Rice, Corn Starch, Salt, Canola and/or Rice Bran Oil, Tripotassium Phosphate, Color Added. Vitamin E (mixed tocopherols) Added to Preserve Freshness. Vitamins and Minerals: Calcium Carbonate, Zinc and Iron (mineral nutrients), Vitamin C (sodium ascorbate), A B Vitamin (niacinamide), Vitamin B_6 (pyridoxine hydrochloride), Vitamin B_2 (riboflavin), Vitamin B_1 (thiamin mononitrate), Vitamin A (palmitate) A B Vitamin (folic acid), Vitamin B_{12} Vitamin D_3.
CONTAINS WHEAT INGREDIENTS.

MAY CONTAIN GENETICALLY ENGINEERED INGREDIENTS

This package is sold by weight, not by volume. You can be assured of proper weight even though some setting of contents normally occurs during shipment and handling.
F3851607538 SSG 3917380538