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Agricultural Biotechnology and Organic Agriculture: National Organic Standards and Labeling of GM Products

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The National Organic Program, introduced in 2002, has explicitly linked the markets for organic and genetically modified (GM) products through the provision that organic-labeled food should be free of GM ingredients. This paper models the demand links between the organic, GM, and conventional products and analyzes the market and welfare effects of the introduction of labels for products of biotechnology under the new organic standards.

Key words: agricultural biotechnology, genetically modified products, mandatory labeling, national organic standards, organic agriculture.

The introduction of genetically modified products (GMPs) into the food system and the significant growth of organic agriculture are among the most notable features of the increasingly industrialized agri-food sector. They have both received considerable attention in the economics literature with the main focus being on the optimal regulatory responses as they relate to the introduction of standards for, and labeling of, genetically modified (GM) and organic food products.

Labeling of GMPs has been a contentious issue sparking an ongoing international debate among parties holding significantly different views on the need for regulation of products of biotechnology. Whereas the United States has argued the "substantial equivalence" of first-generation GMPs to their conventional counterparts and has been opposing the labeling of such products, the European Union advocates mandatory labeling of GMPs based on its "precautionary principle" and a vocal consumer opposition rooted in concerns about the health and environmental effects of products of biotechnology.[1]

Regarding the organic sector, the process of establishing national standards for organic food in the United States generated a significant public response, with the dialogue among interest groups extending over a good part of the last decade. The demands for national organic standards were satisfied in 2002 with the introduction of the National Organic Program (NOP). In addition to instituting uniform standards for organic-labeled food, an important feature of NOP is that it explicitly links the markets for organic and GM products. In particular, one of the NOP provisions is that food labeled as organic should be free of GM ingredients.[2]

Given the credence nature of the first-generation GM products and the consequent inability of the American consumer to observe the type of the product (i.e., GM versus conventional) under the current no-labeling regime, the introduction of NOP can be expected to have important ramifications for the markets of GM, conventional, and organic food products. The reason is that under the current regulatory framework, purchase of organic products provides the main option available to consumers exhibiting a preference for non-GM food—the NOP has made the organic label equivalent to a "non-GM" label.[3] Interestingly, although the maintenance of the current no-labeling regime appears advantageous for the organic sector, a number of prominent organic industry associations, such as the Organic Trade Association, advocate the introduction of labels for products of biotechnology (see http://www.ota.com/pp/otaposition/geos.html).

The objective of this paper is to model the demand links between the organic, GM, and conventional food products and systematically analyze the market and consumer welfare effects of a change in the labeling regime for products of biotechnology in the presence of NOP. In

1. *In addition to the EU, the list of countries that require labeling of GM products includes Australia, Japan, and South Korea.*

2. *It is important to note that according to the NOP "certification is to an organic process not to an organic product." More specifically, "the NOP provides for certification of an organic process or system of agriculture not certification of products, themselves, as 'organic'" (see the Labeling–Clarifications section of the NOP standards at http://www.ams.usda.gov/nop/NOP/standards/FullText.pdf, p.150).*

3. *Other options available to consumers averse to GMPs include conventional products that are voluntarily labeled as "non-GM" (for a listing of suppliers of such non-GM products, see https://www.non-gmoreport.com/Order-Non-GMO-Sourcebook/).*

analyzing the ramifications of the introduction of labels for GMPs, the paper compares and contrasts consumer purchasing decisions and welfare under (a) no labeling and (b) mandatory labeling of GM products.

The study builds on previous work by Giannakas (2002) and Giannakas and Fulton (2002) that examine the effects of different regulatory and labeling regimes in markets for organic and GM products, respectively.[4] Although these studies have examined the two markets in isolation, this paper explicitly considers the demand links between the GM and organic food product markets created by the new regulation governing the organic sector.

In analyzing the market and welfare effects of labeling the GM products in the presence of NOP, this paper explicitly accounts for differences in consumer preferences for GM, conventional, and organic food products. Consumer heterogeneity in terms of preferences for different food products is a key component in our model, and it is critical in explaining the coexistence of markets for products with different process attributes (i.e., produced through different production processes).

The rest of the paper is organized as follows. The next section presents a simple model of heterogeneous consumer preferences for GM, conventional, and organic food products. The sections following analyze consumer purchasing decisions and welfare with and without labeling of GMPs and determine the market and welfare effects of the introduction of labels for GMPs. The final section summarizes and concludes the paper.

Product and Consumer Characteristics

Consider a product that is available in GM, conventional (non-GM), and organic forms.[5] The product in question can be seen as having two attributes—the first of these is the set of observable physical characteristics, while the second is the process through which the good is produced.

The GM, conventional, and organic versions of this product share the same observable physical characteristics but differ in the process through which they have been produced.[6] The three forms of the product are treated by consumers as *vertically differentiated products*—if offered at the same price, all consumers exhibiting a preference for the process through which those products are produced would prefer the organic version of the product, while if only the conventional and GM versions were available and priced the same, those consumers would buy the conventional form of the product. Although the GM, conventional, and organic forms of the product are, by definition, uniformly quality ranked by consumers who value the process attributes of these products, consumers differ in their willingness to pay for the perceived quality differences between the three goods.[7]

To capture these elements, consider a consumer that consumes one unit of either the GM, the conventional, or the organic form of the product in question, and the purchasing decision represents a small share of her total budget. Her utility function can be written as

$U_{gm} = U - p_{gm} - \gamma\alpha$ if a unit of GM product is consumed,
$U_c = U - p_c - \delta\alpha$ if a unit of conventional product is consumed, and
$U_o = U - p_o + \beta\alpha$ if a unit of organic product is consumed, (1)

where U_{gm}, U_c, and U_o are the utilities associated with the consumption of the GM, conventional, and organic versions of the product, respectively. The terms p_{gm}, p_c, and p_o denote the equilibrium prices of the GM, the conventional, and the organic products, respectively. The parameter U is the per-unit utility derived from the observable physical characteristics of the product. It is assumed that U exceeds the prices of the different products and is common to all consumers.[8] The terms γ and δ are non-negative utility discount factors associated

4. *On issues pertaining to GM labeling, see also Caswell (1998), Crespi and Marette (2003), Runge and Jackson (2000), Fulton and Giannakas (2004), and Lapan and Moschini (2004).*

5. *One example of a product that could be supplied in a conventional, GM, and organic form is tomatoes. A second example is soy oil (made from conventional, GM, or organic soybeans).*

6. *By assuming that the different versions of the product share the same observable physical characteristics, the analysis applies to agricultural products whose observable physical characteristics are not affected by the production process.*

7. *Premiums paid for organic food products vary significantly by product and region (Giannakas, 2002; Thompson & Kidwell, 1998). The level of consumer aversion to GM products both between and within countries is also highly variable (Giannakas & Fulton, 2002).*

8. *It should be noted that if the production process affects the observable physical characteristics of the product (such as the cosmetic appearance of organic tomatoes, for instance), the utility derived from those characteristics will vary among the different goods, and the products may become horizontally differentiated.*

with the consumption of GM and conventional products, respectively, and β is a non-negative utility enhancement factor associated with the consumption of the organic product. The parameter α takes values between zero and one and differs according to consumer capturing heterogeneous consumer preferences (and thus heterogeneous willingness-to-pay) for the three products.[9]

Specifically, the characteristic α can be seen as capturing differences in consumer preferences with regards to the process attributes of the three goods—the way they have been produced. The greater is α, the greater is the consumer aversion to (and the discount in utility from the consumption of) goods whose production is facilitated either by genetic engineering (i.e., GM products) or by the application of chemical fertilizers and pesticides (i.e., conventional products), and the greater is the utility derived from the organically grown version of the product. Thus, for a consumer with attribute α, the terms $\gamma\alpha$ and $\delta\alpha$ give the utility discount from consuming the GM and conventional products, respectively, and the term $\beta\alpha$ is the utility enhancement from consuming the organic version of the product.[10]

To save on notation, in the following analysis the parameter δ is normalized to zero. With δ equal 0, the term $\gamma\alpha$ reflects the level of aversion to GMPs of consumers with different values of α.[11] For tractability, the analysis assumes that consumers are uniformly distributed between the polar values of α. The implications of relaxing this assumption are straightforward and are discussed throughout the text.

Consumer Decisions when GM Products are Not Labeled

Consider first the situation where the GM version of the product is not labeled (and the organic version is certified and labeled as such). In this case, the GM and conventional products are marketed together, and the price faced by the consumer, p_{nl}, is the same regardless of which product is purchased. Note that when the GM product is not labeled, the presence or absence of genetic modification is not detectable by consumers with either search or experience (i.e., genetic modification is a credence attribute; see Darby & Karni, 1973, and Nelson, 1970). The lack of information about the type of the product being sold means that consumers are uncertain about the nature of the product they purchase. Assuming a probability of ψ that the nonlabeled product is GM, consumer utility is now[12]

$U_{nl} = U - p_{nl} - \psi\gamma\alpha$ if a unit of nonlabeled product is consumed, and

$U_o = U - p_o + \beta\alpha$ if a unit of certified organic product is consumed, (2)

where U_{nl} is the expected utility associated with the unit consumption of nonlabeled product; that is, $U_{nl} = \psi U_{gm} + (1 - \psi)U_c = \psi(U - p_{nl} - \gamma\alpha) + (1 - \psi)(U - p_{nl}) = U - p_{nl} - \psi\gamma\alpha$.

A consumer's purchasing decision is determined by comparing the utilities derived from the nonlabeled product and its organic counterpart. Figure 1 illustrates the decisions and welfare of consumers. The upward-sloping curve graphs utility levels when the organic product is purchased, and the downward-sloping line shows the utility when the nonlabeled product is purchased for different levels of the differentiating attribute α. The intersection of the two utility curves determines the level of the differentiating attribute that corresponds to the indifferent consumer. The consumer with differentiating characteristic α_{nl}, given by

$$\alpha_{nl}: U_{nl} = U_o \Rightarrow \alpha_{nl} = (p_o - p_{nl}) / (\beta + \psi\gamma), \quad (3)$$

is indifferent between consuming a unit of nonlabeled product and a unit of organic—the utility of consuming these two products is the same. Consumers located to the left of α_{nl} (i.e., consumers with $\alpha \in [0, \alpha_{nl})$) purchase the nonlabeled product, while those located to the right of α_{nl} (i.e., consumers with $\alpha \in (\alpha_{nl}, 1]$) buy its organic counterpart. Aggregate consumer welfare is given by the area underneath the effective utility curve shown as the (bold dashed) kinked curve in Figure 1.

9. Note that consumers with an α value of zero would be indifferent between the GM, organic, and conventional versions of the product if those were offered at the same price.

10. In this context, $U - \gamma\alpha$, $U - \delta\alpha$, and $U + \beta\alpha$ represent the consumer willingness-to-pay (WTP) for a unit of the GM, the conventional, and the organic products, respectively. Subtracting the relevant equilibrium prices from these WTP values provides an estimate of the consumer surplus associated with the consumption of these goods.

11. Note that when δ is positive, the level of consumer aversion to GMPs is given by $(U - \delta\alpha) - (U - \gamma\alpha) = (\gamma - \delta)\alpha$.

12. Assuming that consumers have rational expectations, the probability that the nonlabeled product is GM reflects the share of the GM product in total production of the nonlabeled good. The greater the production share of the GM version of the product, the greater the likelihood that the nonlabeled product is GM (Giannakas & Fulton, 2002).

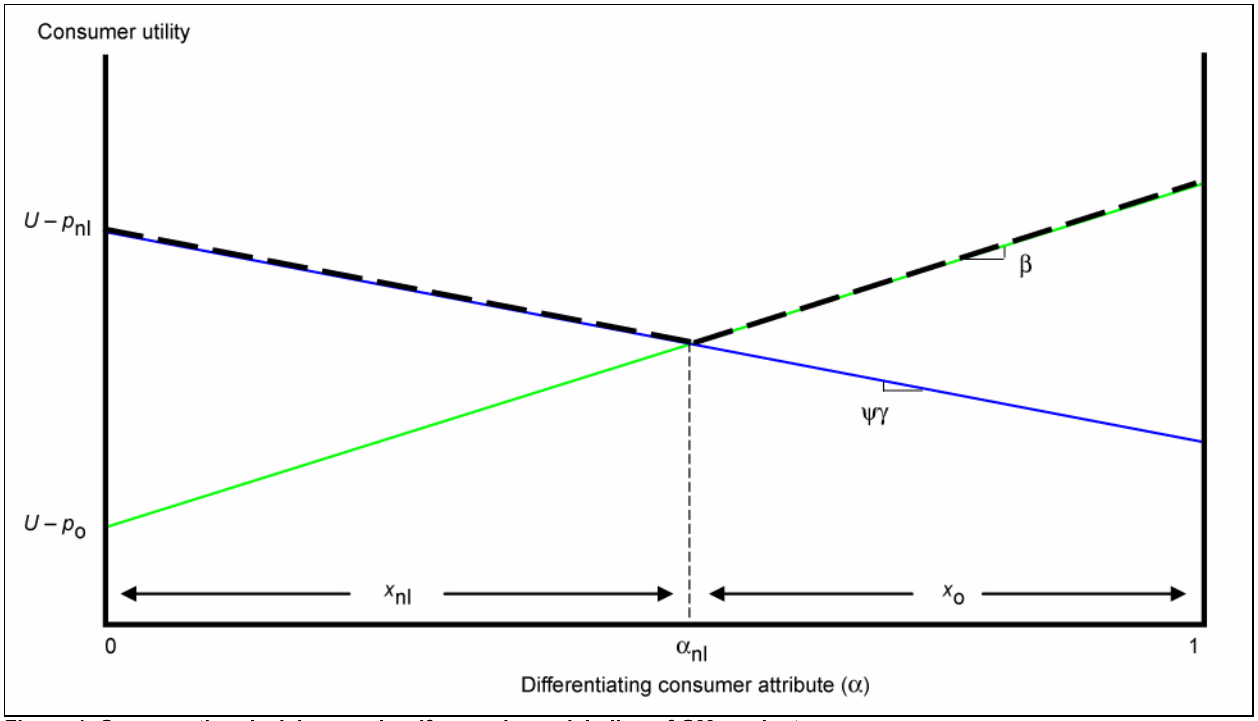

Figure 1. Consumption decisions and welfare under no labeling of GM products.

When consumers are uniformly distributed with respect to their differentiating attribute α, the level of α corresponding to the indifferent consumer, α_{nl}, also determines the market share of the nonlabeled product. The market share of the organic product is given by 1 – α_{nl}. By normalizing the mass of consumers at unity, the market shares give the consumer demands for the nonlabeled, x_{nl}, and the organic products, x_o, respectively. In what follows, the terms *market share* and *demand* will be used interchangeably to denote x_{nl} and/or x_o. Formally, x_{nl} and x_o can be written as

$$x_{nl} = (p_o - p_{nl}) / (\beta + \psi\gamma) = \alpha_{nl} \text{ and} \quad (4)$$

$$x_o = [\beta + \psi\gamma - (p_o - p_{nl})] / (\beta + \psi\gamma). \quad (5)$$

Equations 4 and 5 show that if $p_o \le p_{nl}$, all consumers will buy the organic product (i.e., $x_o = 1$ and $x_{nl} = 0$). In other words, for any positive quantity of nonlabeled product to be demanded (i.e., for x_{nl} to be positive), p_{nl} should be less than p_o.

There are at least three reasons why the nonlabeled product will be priced lower than its organic counterpart. First, organic food producers must incur certification costs that have been estimated to account for 2–5% of total sales value (Food and Agriculture Organization of the United Nations, 1999). Second, the labeling of organic foods implies increased segregation costs incurred by organic producers in keeping their produce separate from conventional and GM produce. Third, it is assumed that the supply of organic food entails increased production costs. Some, if not all, of the additional cost will be transferred to the consumer of the organic product.

Before concluding this section, it should be noted that the analysis can be easily modified to examine cases where consumers are not uniformly distributed with respect to their value of α. When the distribution of consumers is continuous (but not uniform), consumer demand for the different products depends on its skewness; that is, the more skewed the distribution towards one, the greater the market share of, and the demand for, the organic product when the GM and conventional products are marketed together (i.e., GM products are not labeled).

Consumer Decisions under Mandatory Labeling of GM Products

Consider now the consumer choice problem in an institutional arrangement with a mandatory GM labeling regime in place.[13] In this case, conventional and GM products are segregated and marketed separately, and consumers have a choice between the conventional product, the GM-labeled product, and their certified organic counterpart. Consumer utility is given by Equation 1 (with δ normalized to zero), and a consumer's purchasing decision is determined by the relative utilities derived from the consumption of the three goods.

Note that the GM and conventional products are not necessarily priced the same. Given the vertical differentiation of the three products and their uniform quality ranking by consumers, for any positive quantity of GM-labeled product to be demanded, p_{gm} should be less than p_c. Similarly, for any positive quantity of conventional product to be demanded, p_c should be less than p_o.

As pointed out by Giannakas and Fulton (2002), there are at least two reasons why the GM product will be priced lower than its conventional counterpart. First, mandatory labeling means increased marketing and segregation costs (Kalaitzandonakes, Maltsbarger, & Barnes, 2001). These transaction costs associated with identity preservation cause consumer prices to rise. The majority of these costs are incurred by the conventional product chain, which in turn implies that consumers of the conventional product face a greater price increase. Second, the producer-oriented, first-generation GM technology generates production cost savings at the farm level. Some, if not all, of the cost savings may be transmitted to the consumer of the GM product. Although the conventional product is expected to be priced higher than the GM product, it is expected to be priced lower than its organic counterpart for the reasons mentioned in the previous section (i.e., certification, segregation, and higher production costs incurred in the organic product supply chain).

Figure 2 depicts the consumption decisions under mandatory labeling of GMPs when $p_{gm} < p_c < p_o$ and the consumer preferences are such that all three products enjoy positive shares of the market. In this case, the consumption share of the GM product, x_{gm}, is determined by the intersection of the U_{gm} and U_c utility curves (i.e., x_{gm}:$U_{gm} = U_c$) and equals

$$x_{gm} = (p_c - p_{gm}) / \gamma, \tag{6}$$

while the demand for organic product, x'_o, is given by 1 – α_T, where α_T corresponds to the consumer who is indifferent between the conventional and organic products (i.e., α_T:$U_c = U_o \Rightarrow \alpha_T = (p_o - p_c) / \beta$). Thus,

$$x'_o = [\beta - (p_o - p_c)] / \beta. \tag{7}$$

Finally, the demand for the conventional product, x_c, is given by $1 - (x_{gm} + x'_o)$, or

$$x_c = [\gamma(p_o - p_c) - \beta(p_c - p_{gm})] / \beta\gamma. \tag{8}$$

The preceding analysis indicates that the market shares of the GM, organic, and conventional products are determined by the consumer attitudes towards these products and their relative prices, which are determined, in turn, by the relative size of the segregation and labeling costs in the three supply channels, the cost savings associated with the GM technology, the market power in the GM product supply chain (which determines the extent to which production costs savings are transferred to the consumer), and the structure of the organic and conventional supply channels.

Equation 8 indicates that when the price of the GM version of the product is sufficiently lower than the price of its conventional counterpart, and/or when the price difference between the organic and conventional products is relatively low, and/or when the consumer aversion to GM products is not significant, and/or when the consumer preference for organic food is strong, the conventional product will be driven out of the market (i.e., $x_c = 0$)—consumers with relatively low values of the differentiating attribute α will opt buying the cheaper GM product, while consumers with relatively high values of α will prefer consuming the organic.

Formally, when the combination of prices and preference parameters are such that $\gamma / \beta \leq (p_c - p_{gm}) / (p_o - p_c)$, the utility curve U_c in Figure 2 lies underneath the curves U_{gm} and/or U_o for all consumers (i.e., $\forall\alpha$) and $x_c = 0$. In this case, the demand for the GM product, x^+_{gm}, is determined by the intersection of U_{gm} and U_o curves (i.e., x^+_{gm}:$U_{gm} = U_o$) and equals

$$x^+_{gm} = (p_o - p_{gm}) / (\beta + \gamma). \tag{9}$$

13. Although the analysis assumes that only the GM product is required to be labeled, the results are more general and apply to the cases where only the conventional or both the GM and conventional products have to be labeled. Specifically, when only GM products are labeled, unlabeled products will be perceived as conventional. Similarly, if conventional products are required to be labeled as such, unlabeled products will be perceived as being GM. It should be noted that our model can also be used to analyze the case of voluntary labeling. Obviously, when labeling is voluntary it is only producers of the conventional product that have economic incentives to use labels and signal the nature of their produce.

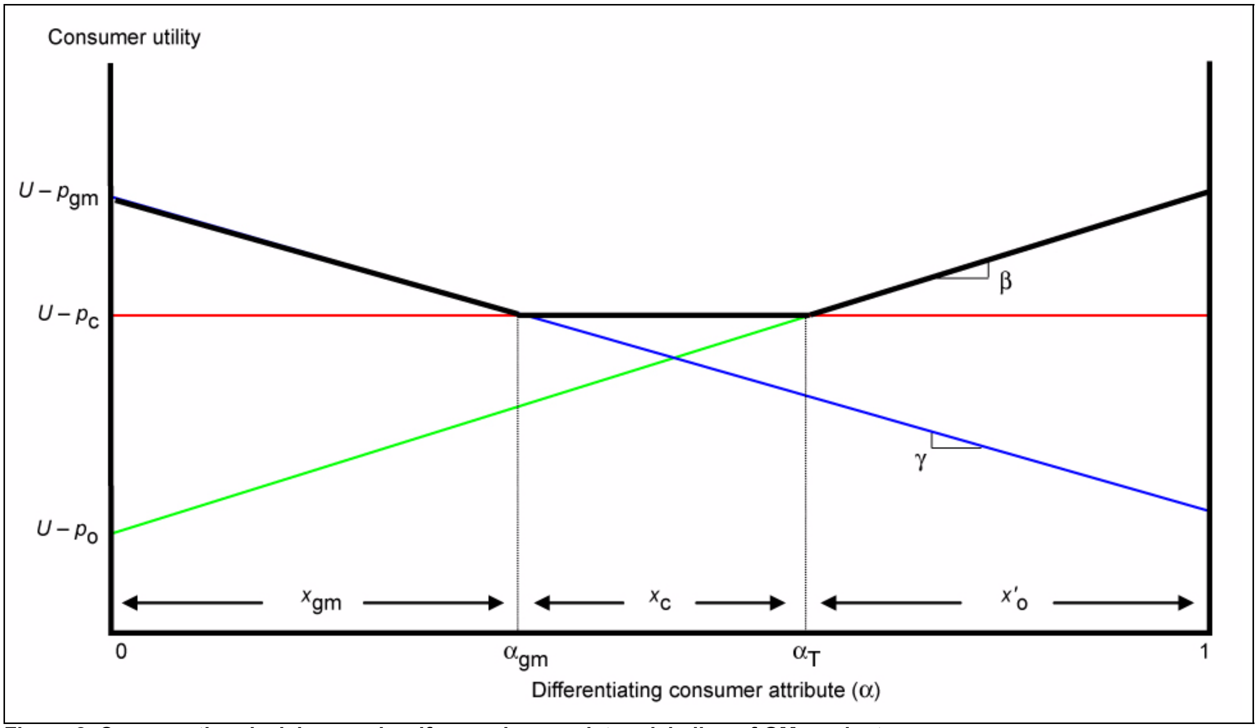

Figure 2. Consumption decisions and welfare under mandatory labeling of GM products.

The demand for the organic product, x^+_o, is then given by $1 - x^+_{gm}$, or

$$x^+_o = [\beta + \gamma - (p_o - p_{gm})] / (\beta + \gamma). \quad (10)$$

Equations 9 and 10 indicate that the consumer demand for GM (organic) product increases (falls) with an increase in $p_o - p_{gm}$ and falls (increases) with an increase in the preference parameters γ and β.

Market and Welfare Effects of Mandatory Labeling of GM Products

Having analyzed the consumer purchasing decisions and welfare under the no-labeling and labeling regimes, we can now determine the ramifications of GM labeling for the welfare of consumers and the demand for GM, conventional, and organic food products. Figure 3 depicts the effective utility curves under no labeling (dashed kinked curve) and mandatory labeling (solid kinked curve) when $p_{gm} < p_{nl} < p_c < p_o$ and the prices and preference parameters are such that the conventional product enjoys positive share of the market under mandatory labeling of GMPs (i.e., $\gamma / \beta > (p_c - p_{gm}) / (p_o - p_c)$ and the utility curve U_c lies above U_{gm} and U_o over some values of α).

In this case, the introduction of labels increases consumer welfare by the shaded area ΔCW in Figure 3 while reducing the consumer demand for the organic product. Consumers with relatively low aversion to interventions in the production process (i.e., consumers with $\alpha \in [0, \alpha_{gm})$) realize an increase in their welfare under labeling of GMPs, because the utility increase from the purchase of the cheaper GM product outweighs the utility discount from its consumption. At the same time, for consumers with intermediate values of α (i.e., consumers with $\alpha \in [\alpha_{gm}, \alpha_{nl}]$) the utility increase from the consumption of the (identity-preserved) conventional product exceeds the utility discount from its higher price.

In addition, the availability of the conventional product in the labeling case eliminates the exclusivity of the organic sector in the supply of non-GM product and results in some consumers that would purchase the organic product under the no-labeling regime switching to its conventional counterpart. In particular, consumers with $\alpha \in (\alpha_{nl}, \alpha_T]$ find it optimal to switch their consumption from the organic to the cheaper conventional product.[14]

Obviously, when the assumption of a uniform distribution of consumers is relaxed, the effects of mandatory labeling depend on the skewness of the distribution. The

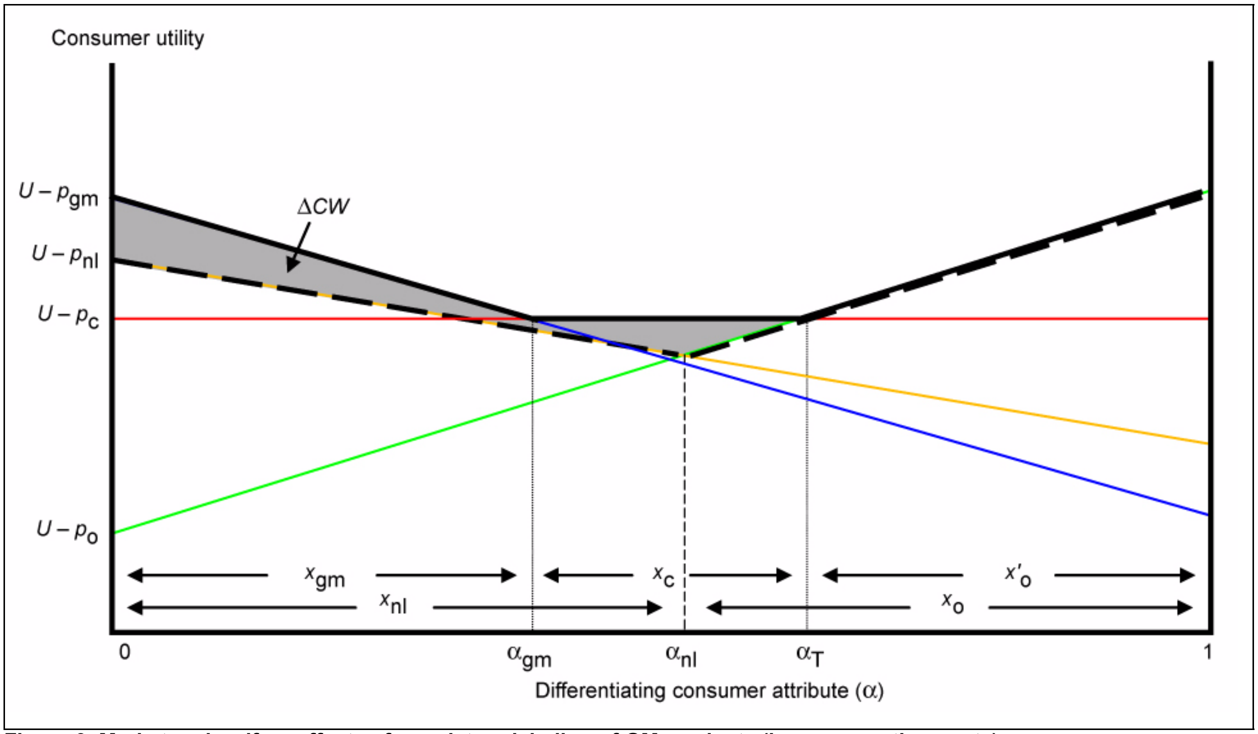

Figure 3. Market and welfare effects of mandatory labeling of GM products (low segregation costs).

greater the number of consumers with a relatively low aversion to interventions in the production process (i.e., the more skewed towards zero is the distribution of consumers with respect to their value of α), the greater the welfare gains from the introduction of labels and the lower the consumer demand for conventional and organic food products.

Comparative statics results can easily be derived from Figure 3. For instance, an increase in p_{gm} will reduce ΔCW and will increase the demand for conventional product. Similarly, an increase in the marketing and segregation costs associated with labeling of GMPs will increase the prices of conventional and GM products, which will shift the U_c and U_{gm} curves downward and will reduce the consumer benefits from the introduction of labels.

As mentioned previously, the price effect of increased segregation costs will be more profound in the conventional product supply chain (i.e., the downward shift of U_c will exceed that of U_{gm}). This negative externality that the existence of GMP imposes on the conventional product will result in reduced demand for the conventional product and increased demand for its organic counterpart. The greater the marketing and segregation costs, the lower the consumer welfare under labeling of GMPs, the lower the consumer demand for conventional product, and the greater the demand for organic product. For sufficiently high segregation costs, the conventional product is driven out of the market (i.e., U_c lies underneath U_{gm} and/or U_o $\forall\alpha$ and $x_c = 0$), and the demand faced by the organic sector can exceed that under no-labeling of GMPs.

The reasoning behind this counterintuitive increase in the demand for organic product under labeling of GMPs is as follows. The exit from the market of the conventional product when marketing and segregation costs are high restores the exclusivity of the organic sector in supplying a non-GM product (an exclusivity that is lost when the conventional product is present). In addition to avoiding the loss of consumers to the conventional product (consumers with $\alpha \in (\alpha_{nl}, \alpha_T)$ in Figure 3), the high segregation costs can make the GM alternative more costly. For certain values of the prices and preference parameters (identified below), U_{gm} lies

14. Note that, for simplicity of exposition, Figure 3 is drawn on the assumption of free entry into the market of the organic product. When this assumption is relaxed, the reduced demand for the organic product caused by the introduction of labels reduces p_o. This price decrease shifts the U_o curve in Figure 3 upwards and results in welfare gains for consumers of the organic product.

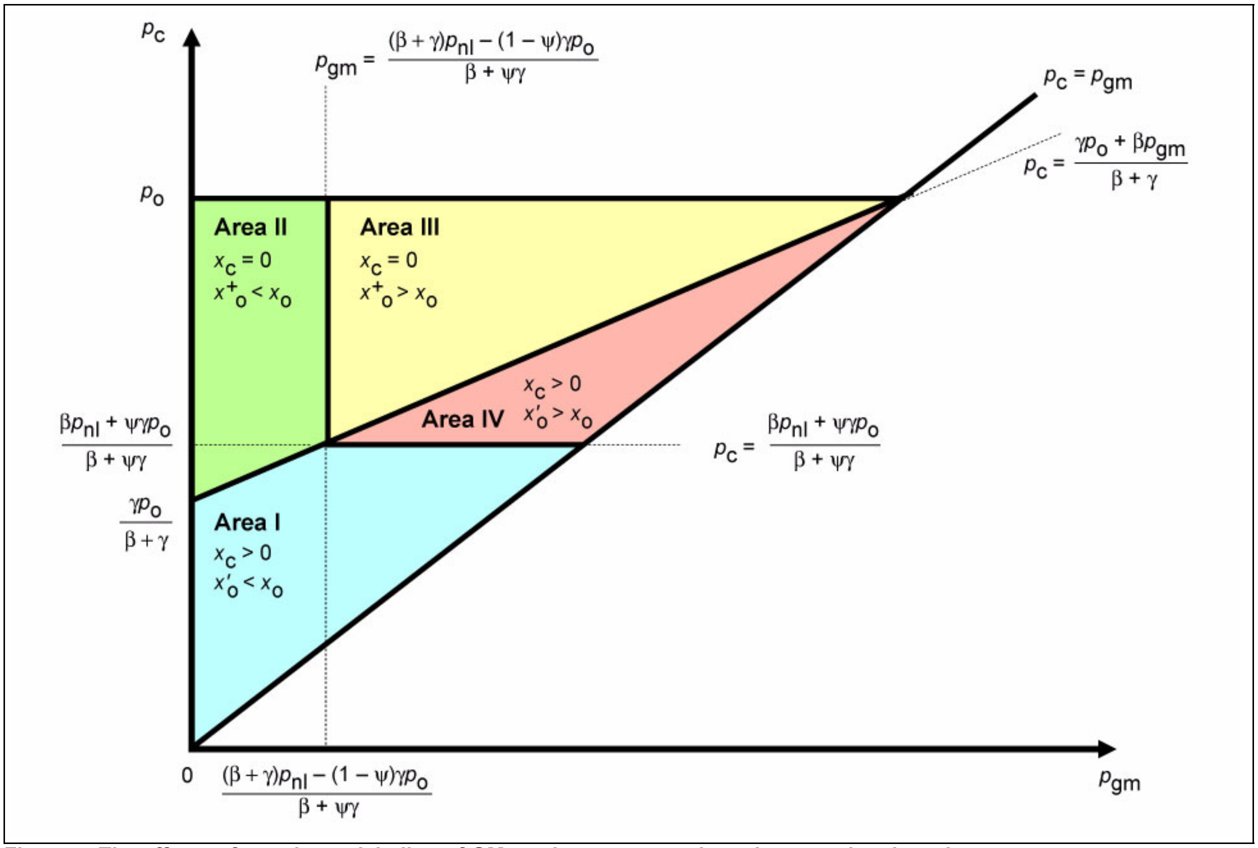

Figure 4. The effects of mandatory labeling of GM products on organic and conventional products.

below U_{nl} at the point of intersection with the U_o curve, which results in increased demand for the organic product under labeling of GMPs. In this context, an expectation of high marketing and segregation costs might help rationalize the support of organic industry associations for the establishment of mandatory labeling of GMPs.

Figure 4 graphs p_c against p_{gm} and summarizes the different possibilities on the effects of labeling the GM products on the markets for their organic and conventional counterparts. The relevant part of Figure 4 (i.e., the part where $p_o > p_c > p_{gm}$) is divided into four areas. In Area I, relatively low p_c and p_{gm} result in positive market share for the conventional product and a reduction of x_o after the introduction of labeling. High p_c (due to high segregation costs incurred in the conventional supply channel, for instance) drive the conventional product out of the market (Area II and Area III). Even with the conventional product priced out of the market, when the price of the GM product is very low (due to significant cost savings from the GM technology, for instance), the market share of the organic product can still fall after the introduction of labeling (Area II). High prices of the GM product (due to high segregation and labeling costs and/or significant market power along the GM supply channel, for instance) reverse the effect of GM labeling on the demand for the organic product (Area III and Area IV), whereas when relatively high p_{gm} are combined with medium prices of the conventional product, the outcome is positive x_c and increased market share of the organic product in the presence of labels for the GM products (Area IV).

Note that the size and shape of the areas depicted in Figure 4 are determined by the position of their boundaries (i.e., curves $p_c = (\gamma p_o + \beta p_{gm}) / (\beta + \gamma)$, $p_c = (\beta p_{nl} + \psi\gamma p_o) / (\beta + \psi\gamma)$, and $p_{gm} = [(\beta + \gamma)p_{nl} - (1 - \psi)\gamma p_o] / (\beta + \psi\gamma)$), which in turn are determined by the prices of the different products, the consumer aversion to GMPs, the preference for organic food, and the share of the GM product in total production of the nonlabeled good, ψ. When $p_o / p_{nl} > (\beta + \gamma) / (1 - \psi)\gamma$, for instance, the curve $p_c = (\gamma p_o + \beta p_{gm}) / (\beta + \gamma)$ lies above the curve $p_c = (\beta p_{nl} + \psi\gamma p_o) / (\beta + \psi\gamma)$, and Area II in Figure 4 vanishes. In this case, an elimination of the conventional product under labeling of GMPs always results in enhanced market share of its organic counterpart.

Table 1. Market and consumer welfare effects of mandatory labeling of GM products.

Scenarios	U	p_{gm}	p_c	p_o	p_{nl}	γ	β	x_{gm}	x_c	x_o	x_{nl}	Changes in consumer welfare %ΔCW[a]
	Parameter values							Market shares				
No labeling (**ψ = 0.7; benchmark case**)	8.01	—	—	8	4.5	3	1.5	—	—	0.02	0.98	
Labeling: Area I[b] (**$x_c > 0, x'_o < x_o$**)	8.01	4.3	6.5	8	—	3	1.5	0.74	0.246	0.014	—	7
Labeling: Area II (**$x_c = 0, x^+_o < x_o$**)	8.01	3.5	6.5	8	—	3	1.5	0.993	0	0.007	—	19.88
Labeling: Area III (**$x_c = 0, x^+_o > x_o$**)	8.01	4.7	6.9	8	—	3	1.5	0.74	0	0.26	—	-20.75
Labeling: Area IV (**$x_c > 0, x'_o > x_o$**)	8.01	4.5	6.6	8	—	3	1.5	0.7	0.24	0.066	—	-13.57

[a] % changes in consumer welfare are estimated relative to the benchmark case of No Labeling.
[b] The areas in Table 1 correspond to the areas depicted in Figure 4.

Table 1 provides a numerical example that illustrates the market and consumer welfare effects of the introduction of labels for GMPs under different prices of the GM and conventional products (due to different segregation and labeling costs, for instance). Four different labeling scenarios, corresponding to combinations of p_c, p_{gm}, and p_o that give rise to the four cases depicted in Figure 4, are compared to the benchmark case of no labeling with ψ = 0.7 (i.e., the production share of the GMP is 70%).[15] Parameter values are set so that in the absence of labeling, the consumption shares of the organic and nonlabeled products are 2% and 98%, respectively, reflecting current consumption shares of these products (United States Department of Agriculture Foreign Agricultural Service, 2005).

When labels for GM products are introduced under relatively low segregation costs, and p_{gm} is 34% and 46% less than p_c and p_o, respectively, the market share of the organic product falls to 1.4%, and consumer welfare increases by 7% relative to the benchmark case of no labeling (Area I in Figure 4). When the price of the GM product is 46% below p_c and 56% below p_o, the conventional product is priced out of the market, and the organic product's market share is reduced by two thirds (i.e., to 0.7%) after the introduction of labels (Area II in Figure 4). The very low GM product price under this labeling scenario leads to an increase in consumer welfare by about 20%.

When labels for GMPs are introduced under relatively high segregation costs and p_c is 47% greater than p_{gm} and 13.75% below p_o, the conventional product is priced out of the market, the market share of the organic product increases to 26%, and consumer welfare is reduced by 20.75% (Area III in Figure 4). Finally, when p_c is 47% greater than p_{gm} and 17.5% below p_o, all three products enjoy positive market shares, and the share of the organic product increases to 6.6% after the introduction of labels for GMPs (Area IV in Figure 4). In this case, consumer welfare decreases by 13.57% relative to the benchmark case of no labeling.

Summary and Concluding Remarks

The National Organic Program introduced in 2002 has explicitly linked the markets for organic and genetically modified products through the provision that organic-labeled food should be free of GM ingredients. This paper models the demand links between the organic, GM, and conventional products and analyzes the effects of the introduction of labels for products of biotechnology on the markets for these products.

Analytical results show that the introduction of labels for GMPs has important ramifications for the markets of organic, conventional, and GM products.

15. *Production shares of GMPs vary with the product considered. For instance, the production shares of GM soybeans, cotton, and corn in 2004 were 85%, 76%, and 45%, respectively. An average share of 70% is used in this example. Regarding the relative prices under no labeling, as noted in footnote 7, the price premiums paid for organic products are highly variable. Thompson and Kidwell (1998) report price premiums ranging from 40% to 175% for fresh fruits and vegetables, while price premiums paid for crops like organic oats and soybeans in 2001 were 41% and 177%, respectively (Streff & Dobbs, 2003). The price premium used in our benchmark case of no labeling is 78% (i.e., p_o is 78% greater than p_{nl}).*

The market and welfare effects of labeling are shown to depend on the size of segregation costs under mandatory labeling of GMPs, the distribution of consumer preferences and the level of aversion to genetic modification, the production share of the GM product in the no-labeling case, the strength of the consumer preference for organic food, and the structure of the different supply channels.

It is shown that although a no-labeling regime for products of biotechnology can be beneficial for the organic sector, when segregation costs are sufficiently high, labeling of GM products can enhance the consumption share and growth of the organic sector. In this context, an expectation of high marketing and segregation costs might help rationalize the (seemingly irrational) support of organic industry associations for the establishment of mandatory labeling of GM products. Although high segregation costs associated with labeling of GM products may benefit the organic sector, they can drive the conventional products out of the market and result in losses in consumer welfare.

Before concluding this paper, it should be pointed out that although our analysis has focused on market and welfare of GM labeling for the (prevalent) case where GM, conventional, and organic food products are vertically differentiated, our framework can be utilized (with some modification) to analyze the ramifications of GM labeling when the production process affects the physical characteristics of organic products making these products horizontally differentiated with their GM and conventional counterparts. Another meaningful extension of this study could be the examination of the effects of GM labeling for agricultural producers and the various middlemen of the three supply channels. Both the analysis of the effects of GM labeling when organic, GM, and conventional products are horizontally differentiated and the determination of the system-wide effects of labeling in the presence of NOP are open to future research.

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