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CONSUMPTION EFFECTS OF GENETIC MODIFICATION: WHAT IF CONSUMERS ARE RIGHT?

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ABSTRACT

This paper develops a model of differentiated consumers to examine the consumption effects of genetic modification (GM) under alternative labeling regimes and segregation enforcement scenarios. Analytical results show that if consumers perceive GM products as being different than their traditional counterparts, genetic modification affects consumer welfare and, thus, consumption decisions. When the existence of market imperfections in one or more stages of the supply chain prevents the transmission of cost savings associated with the new technology to consumers, genetic modification results in welfare losses for consumers. The analysis shows that the relative welfare ranking of the "no labeling" and "mandatory labeling" regimes depends on: (i) the level of consumer aversion to genetic modification, (ii) the size of marketing and segregation costs under mandatory labeling; (iii) the share of the GM product to total production; and (iv) the extent to which GM products are incorrectly labeled as non-GM products.

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1. INTRODUCTION

Consumer concern about genetically modified (GM) food is one of the most notable features of agricultural biotechnology. Unlike farmers who have seen agronomic benefits in the new technology and have quickly adopted transgenic plants such as Bt cotton and corn and herbicide-resistant soybeans and canola (Economic Research Service), consumers have expressed reservations about the foods produced from these crops. Consumer opposition to genetic modification started in Europe and has spread to other countries.

An Angus Reid poll in eight countries (France, Germany, UK, Australia, Canada, U.S., Japan, and Brazil) found that, among people aware of genetically modified foods, 68 per cent on average indicate they would be "less likely" to purchase a food product if they knew it contained genetically modified ingredients. The proportion of respondents expressing aversion to GM foods varied between 57 per cent in the US and 83 per cent in Germany (Economist, 2000). In an earlier poll in the UK (MORI poll), 77 per cent of

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those surveyed favored a ban on GM food. Consumer resistance to genetic modification is founded on health, environmental, moral and philosophical concerns about the "new" practice (Hobbs and Plunkett; Lindner).

In response to this consumer reaction, a number of food companies such as Marks and Spencer, McDonalds, Sainsbury, and Tesco in the UK, Nestle in Switzerland, Carrefour in France, McCains in Canada, and Frito Lay in the U.S., have indicated that they are only accepting/selling non-GM products. Governments in the European Union and elsewhere have also responded by introducing mandatory labeling or by banning specific GM products (i.e. GM corn and canola in Austria, France, Greece, and Luxembourg) (Hobbs and Plunkett; Runge and Jackson). A requirement of the Biosafety Protocol signed by 130 countries in Montreal earlier this year is that shipments of food products that may contain GMOs are to be labeled as such.

While labeling of food products satisfies consumer demand for the right to make informed consumption decisions (Caswell and Mojduszka; Caswell), the introduction of segregation and labeling raises a number of issues that affect everyone in the food chain. One issue is the added costs that segregation and labeling introduce and the economic impact of these costs on consumers. A second issue is that segregation and labeling activities create incentives for the misrepresentation and mislabeling of genetically modified food as traditional food. Although there is a growing literature on the nature and origin of consumer attitudes towards GM products, most of the analysis on the economic consequences of these attitudes is rather heuristic in nature. An exception is the paper by Plunkett and Gaisford who examine the welfare effects of introducing GM products, but do not consider consumer heterogeneity or examine the possibility of mislabeling.

The objective of this paper is to develop a conceptual model that examines the consumption effects of genetic modification under alternative labeling regimes and segregation enforcement scenarios. More specifically, the paper analyzes the effect of genetically modified foods on the welfare and purchasing decisions of consumers under: (i) no labeling; (ii) mandatory labeling under full compliance; (iii) and mandatory labeling when misrepresentation of the type of the product (i.e. mislabeling) occurs.

In analyzing the consumption effects of genetic modification, this paper explicitly accounts for consumer heterogeneity. To capture the different attitudes towards genetic modification, consumers are postulated to differ in the utility they derive from the consumption of GM food and therefore in their willingness to pay for this product. Consumer heterogeneity is critical in understanding how a demand for both GM and non-GM products exists when labeling occurs.

In this paper, the term genetically modified products refers to transgenics – the products in which some form of gene "splicing" has occurred. The new technology is assumed to generate production cost savings while having no effect on product characteristics that are observable by consumers; the analysis thus applies to goods that are credence in nature.

The title of the paper stems from the major result of the analysis, namely that if consumers perceive GM food to be different from its non-GM counterpart, then there is a reasonable expectation that a percentage of consumers will correctly believe that the introduction of GM food lowers their utility and would prefer to see the product banned. The key factors that determine the magnitude of this welfare loss are the degree of aversion to GM foods, the degree to which the cost savings at the farm level are not passed through to consumers, and the magnitude of the costs associated with segregating non-GM products from GM products. Although this group would like to ban GM products, when faced with the introduction of GM products as a given, this group will prefer mandatory labeling to no labeling.

The paper is structured as follows. Section 2 presents the conceptual model of the paper. Sections 3, 4, and 5 examine the effect of genetic modification on consumer decisions and welfare under no labeling, mandatory labeling with full compliance, and mandatory labeling with mislabeling, respectively. Section 6 compares and contrasts the no labeling and the mandatory labeling regimes while Section 7 summarizes and concludes the paper.

2. CONSUMER CHARACTERISTICS AND BEHAVIOR

The rise of consumer concerns over GM products and the diversity of these concerns suggests that consumers differ in their willingness to pay for GM versus non-GM food products. In the simplest case consider a consumer that consumes one unit of either a traditional, a GM, or a substitute product. Assuming that the consumer spends a small fraction of total expenditure on the goods in question, her utility function can be written as:

$$U_t = U - p_t \qquad \text{If a unit of traditional product is consumed}$$

$$U_{gm} = U - p_{gm} - l\,c \qquad \text{If a unit of GM product is consumed}$$

$$U_s = U - p_s \qquad \text{If a unit of a substitute product is consumed}$$

where U_t is the utility associated with purchasing one unit of the traditional product, U_{gm} is the utility associated with purchasing one unit of the GM version of the traditional product, and U_s is the utility associated with purchasing one unit of a substitute product.[1] The price of the traditional product is p_t, the price of its GM counterpart is p_{gm}, and the price of the substitute product is p_s. The parameter U is a per unit base level of utility while the term ë*c* gives the discount in utility from consuming GM product.[2] The parameter ë is a non-negative utility discount factor while the characteristic *c* differs according to consumer and captures the consumer's aversion towards GM products. To simplify the analysis, the characteristic *c* takes values between zero and one. Consumers with large values of *c* prefer the traditional product rather than the GM product, all else equal. The assumption that lc is greater than or equal to zero is consistent with evidence showing that consumers are either indifferent or opposed to genetic modification (Hobbs and Plunkett). The analysis initially assumes that consumers are uniformly distributed between the polar values of *c*. This assumption is then modified to allow a bunching or a concentration of consumers at the ends of the spectrum (i.e. zero and one).

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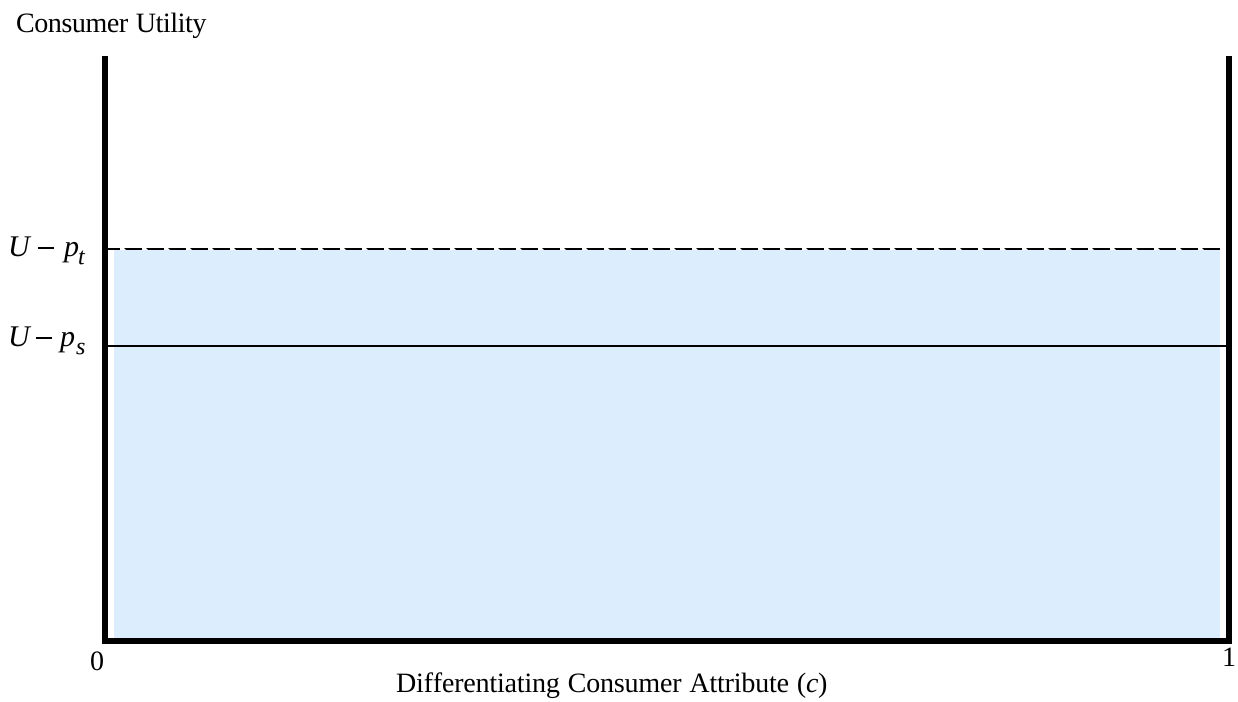
[1] One example of a product that could be supplied in both a traditional and a GM form is margarine made from canola. In this case, butter can be thought of as a substitute product. A second example could be corn chips (made from traditional or GM corn); the substitute product is potato chips. Other examples of traditional, GM, and substitute products include meat coming from animals fed with (traditional or GM) corn or soybean versus meat coming from animals that are barley fed. For simplicity and without loss of generality, it is assumed that the substitute product (butter, potato chips and meat coming from barley fed animals in the preceding examples) is free of GM ingredients. The implications of relaxing this assumption are discussed below in footnote 5.

[2] *U* can also be interpreted as the maximum willingness-to-pay (*wtp*) for a unit of the traditional or the substitute product. In such a case, consumer maximum *wtp* for the GM product equals U- lc. The difference between the *wtp* and the price of the (traditional, the GM, or the substitute) product provides then an estimate of the relevant consumer surplus.

Figure 1 illustrates the situation where no GM product has been introduced. By assumption, the net utility associated with the traditional good is greater than that associated with the substitute good, i.e., $U - p_t > U - p_s$, for all consumers. In such a case, all consumers purchase the traditional good and total consumer welfare is given by the shaded area in Figure 1. The effect of introducing GM products into the market is examined in the sections below.

Figure 1 Consumer Decisions and Welfare Prior to the Introduction of GM Food



3. CONSUMER BEHAVIOR WHEN GM PRODUCTS ARE NOT LABELED

Consider first the situation where a GM product is introduced, but no labeling of the product is carried out. Because the GM product and its traditional counterpart are marketed together, the price faced by the consumer, p_{nl}, is the same regardless of which product is purchased. The lack of information about the type of the product being sold means that consumers are uncertain as to the nature of the product they purchase. Since the presence or absence of the genetic modification is not detectable with either search or experience, the genetic modification can be referred to as a *credence* characteristic (Nelson). Assuming a probability of ø that the non-labeled product purchased is GM, consumer utility is now:[3]

$$U_{nl} = U - p_{nl} - y\,l\,c \qquad \text{if a unit of non-labeled product is consumed}$$

$$U_s = U - p_s \qquad \text{if a unit of a substitute product is consumed}$$

where U_{nl} is the expected per unit utility associated with purchasing the non-labeled product (i.e. $U_{nl} = yU_{gm} + (1-y)U_t$).

The consumption choice of the individual consumer is determined by the relationship between the utilities derived from the non-labeled product and the substitute. More specifically, the consumer with aversion to GM product given by:

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[3] The probability that the non-labeled product is GM can be seen as reflecting the share of the GM product to total production (i.e., the portion of margarine that is genetically modified in the example provided in footnote 1). The greater is the production share of the GM version of the product, the greater is the likelihood that the non-labeled product is GM.

$$c^*_{nl} : U_{nl} = U_s \Rightarrow c^*_{nl} = \frac{p_s - p_{nl}}{y\, l}$$

is indifferent between consuming a unit of non-labeled product and a unit of the substitute–the utility associated with the consumption of these offerings is the same. Obviously, consumers with a lower aversion to genetic modification (i.e. consumers with *c* **Î**[*0*, c^*_{nl})) will prefer the non-labeled product while consumers with higher aversion to GM products (i.e. consumers with *c* **Î**(c^*_{nl}, *1*]) will consume the substitute.[4]

Since consumers have been assumed to be uniformly distributed with respect to their aversion to genetic modification, the level of aversion corresponding to the indifferent consumer, c^*_{nl}, also determines the share of the non-labeled product to total consumption, s_{nl}. The consumption share of the substitute, s_s, is given by 1-c^*_{nl}. More specifically, s_{nl} and s_s can be written as:

$$s_{nl} = \frac{p_s - p_{nl}}{y\, l}\left(= c^*_{nl}\right) \text{ and}$$

$$s_s = 1 - \frac{p_s - p_{nl}}{y\, l}$$

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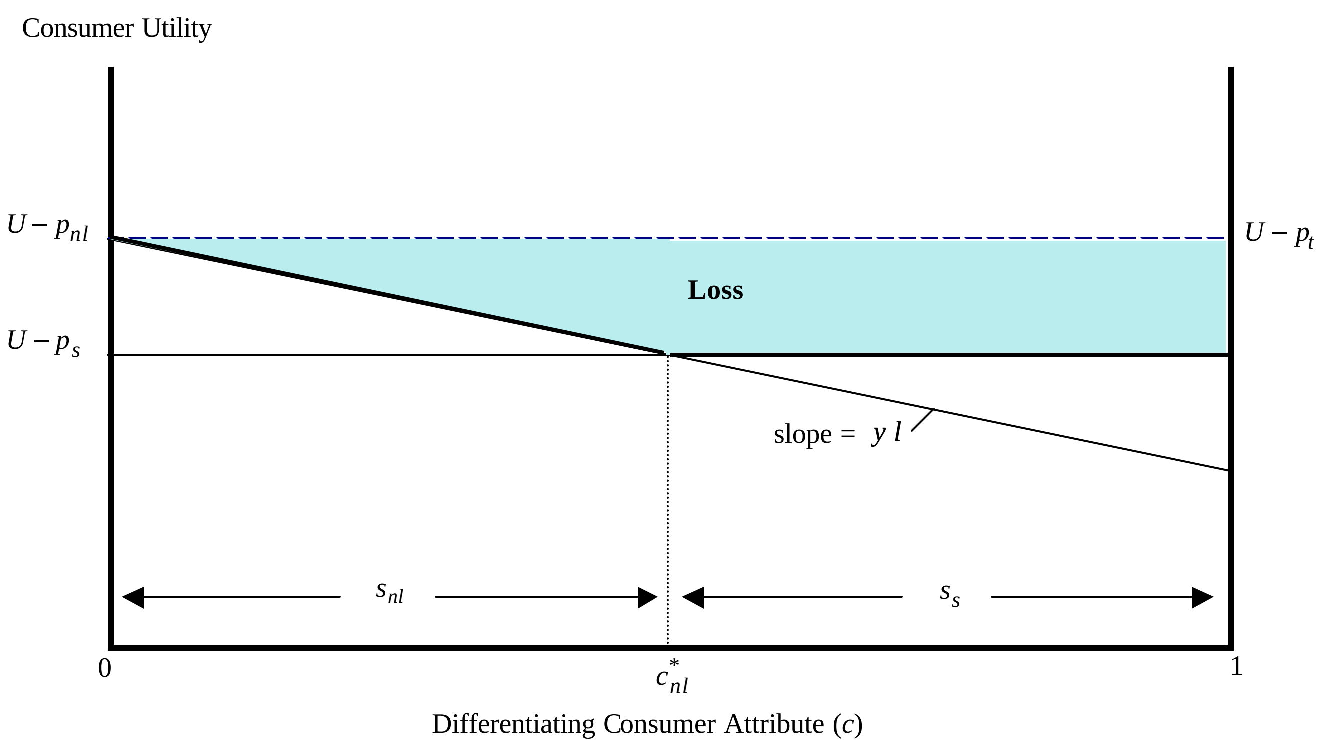
[4] The focus of the analysis on individuals that were consumers of the product prior to its genetic modification guarantees the positive sign of c^*_{nl}. More specifically, for consumers to prefer the product prior to its genetic modification it should hold that $U - p_t > U - p_s$ where p_t represents the price of the product before genetic engineering. Due to the cost savings associated with the new technology, the price of the non-labeled product p_{nl} will be less than, or equal to, p_t.

Figure 2 graphs the determination of s_{nl} and s_s. The downward sloping curve graphs the utility associated with the unit consumption of the non-labeled product for different levels of the differentiating attribute c, while the (continuous) horizontal line shows the utility derived from the consumption of the substitute. The dashed $U - p_t$ curve is the utility curve prior to genetic modification. Thus, Figure 2 is constructed on the assumption that the price of the non-labeled product equals the price of the traditional product, i.e., $p_{nl} = p_t$.

Figure 2 Consumption Decisions and Welfare Effects Under Genetic Modification and No Labeling



The intersection of the two (continuous) utility curves determines the level of the differentiating attribute that corresponds to the indifferent consumer, c_{nl}^*, as well as the consumption shares of the non-labeled product and the substitute. Consumers "located" to the left of c_{nl}^* purchase the non-labeled product while consumers located to the right of c_{nl}^* find it optimal to consume the substitute. Consumer welfare under no labeling is given by the area under the effective utility curve shown as the bold kinked curve in Figure 2.[5]

Comparative statics results can easily be drawn from this model. More specifically, a decrease in the price of the non-labeled product shifts the U_{nl} curve upwards and increases s_{nl} while an increase in the price of the substitute causes a downward shift of the U_s curve that increases s_{nl} (i.e. $\frac{\partial s_{nl}}{\partial p_{nl}} < 0$ and $\frac{\partial s_{nl}}{\partial p_s} > 0$). Finally an increase in l (i.e. an increase in the utility discount from consuming GM product for any level of c) and/or an increase in the likelihood that the non-labeled product is genetically modified, y, cause a clockwise rotation of the U_{nl} curve through the intercept at $U - p_{nl}$ that reduces the share of the non-labeled product to total consumption (i.e. $\frac{\partial s_{nl}}{\partial l} < 0$ and $\frac{\partial s_{nl}}{\partial y} < 0$).

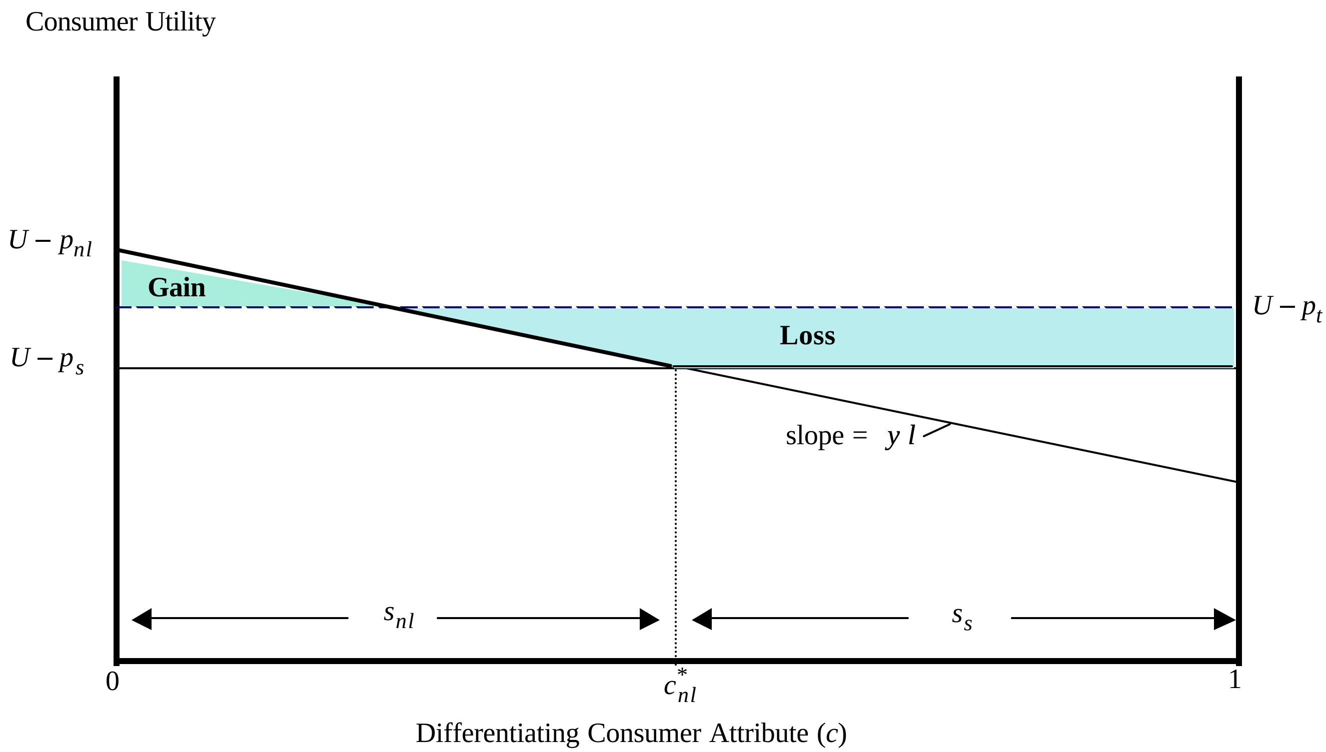
[5] Relaxing the assumption that the substitute product (e.g., butter or potato chips in the examples above) remains free of GM ingredients would result in a clockwise rotation of the utility curve associated with its consumption through the intercept at U-p_s in Figure 2. Similar to the case of the non-labeled product, the slope of the new utility curve for the substitute product would be determined by the utility discount factor l, and the share of the GM version of the substitute product to its total production. Obviously, genetic modification of the substitute product reduces consumer welfare and increases the consumption share of the non-labeled product (i.e. margarine, corn chips) relative to the case where the substitute (i.e., butter or potato chips) remained in its conventional form.

The effect of genetic modification on consumer welfare depends largely on the effect of the technology introduction on the market price of the non-labeled product. The effect of genetic modification on the final price of the product determines whether there will be any gains for consumers as well as the extent of losses due to consumer aversion to GM technology.

More specifically, if the existence of market imperfections in one or more stages of the food chain prevents the transfer of the cost savings to the consumers, the price seen by consumers is not affected by genetic modification. As was noted above, Figure 2 is constructed on the assumption that the price of the non-labeled product remains unchanged, i.e. $p_{nl} = p_t$. Under this assumption, the introduction of GM products represents a loss in welfare to consumers in aggregate. This loss in welfare is given by the hatched area. Although the consumers located at $c = 0$ experience no loss in welfare, all consumers located to the right of this point see their utility falling. The extent of the realized welfare loss depends on the level of consumer aversion to genetic modification c, the utility discount factor l, and the likelihood that the non-labeled product is GM, y.

If the production costs savings due to genetic modification are transferred to consumers (i.e., in the case of a perfectly competitive food chain), the GM technology reduces the price of the product relative to the price prior to genetic modification, p_t, and consumers with relatively low levels of GM aversion will realize an increase in their welfare. Consumers with relatively high aversion to GM products experience a reduction in their welfare since the price effect of genetic modification is outweighed by the utility discount from GM consumption. Figure 3 graphs the effect of genetic modification on consumer welfare when $p_{nl} < p_t$.

Figure 3. Welfare Effects when Genetic Modification Reduces the Market Price, ($p_{nl} < p_t$)



The analysis can be easily modified to examine cases where consumers are not uniformly distributed with respect to their value of c but, rather, are lumped at either end of the continuum. For instance, when consumers do not perceive GM products as being different from their conventional counterparts (i.e. when c=0 for all consumers), the introduction of the new technology will either leave the welfare of consumers unaffected (case where $p_{nl} = p_t$, Figure 2), or will make all consumers better off (case where $p_{nl} < p_t$, Figure 3). On the other hand, when the aversion of all consumers is relatively high (i.e. when c=1 for all consumers), genetic modification will cause consumer welfare to fall. More generally, when the distribution of consumers is continuous (but not uniform), the welfare effects of genetic modification depend on its skewness, i.e., the more skewed is the distribution towards 1, the greater are the losses and the lower are the gains (when $p_{nl} < p_t$) from the introduction of the new technology.

Overall, the results of this section show that genetic modification and no labeling may result in some consumption switching to the substitute good and a net welfare loss. If the number of consumers experiencing a welfare loss is substantial, a ban could be both rational and welfare improving. For net consumer losses to be realized it must hold that: (i) the price decrease from genetic modification (if any) is relatively small; (ii) the discount in utility from consuming the GM product is high; (iii) the likelihood that the non-labeled product is genetically modified is high; and/or (iv) consumers are concentrated at the right hand edge of the aversion spectrum.

4. CONSUMER BEHAVIOR WITH MANDATORY LABELING AND FULL COMPLIANCE

Consider now the consumer choice problem in an institutional arrangement with a mandatory labeling regime in place. In this case, traditional (non-GM) and GM products are segregated and marketed separately. Consumers now have a choice between a non-GM labeled product, its GM labeled counterpart, and a substitute product. Consumer utility is given by:

$U_t' = U - p_t'$ if a unit of non-GM labeled product is consumed

$U_{gm} = U - p_{gm} - l\,c$ if a unit of GM labeled product is consumed

$U_s = U - p_s$ if a unit of a substitute product is consumed

where $p_t^{'}$ is the price of the traditional product after the introduction of the new technology. All other variables are as previously defined.

The GM product and the non-GM product are not necessarily priced the same. In fact for any (positive) quantity of the GM labeled product to be demanded (i.e. for U_{gm} to exceed $U_t^{'}$), p_{gm} should be less than $p_t^{'}$. There are two reasons why the GM product will be priced lower than its traditional counterpart. First, mandatory labeling means increased marketing and segregation costs. These transaction costs associated with identity preservation cause consumer price to rise. The majority of these costs are incurred in the non-GM labeled product chain (Lindner), which, in turn, implies that consumers of the traditional product face a greater price increase.[6] Second, it is assumed that GM technology generates production cost savings at the farm level. Some, if not all, of the cost savings may be transferred to the consumer of the GM product.

Not only does the existence of marketing and segregation costs imply that $U - p_{gm} > U - p_t^{'}$, the size of these costs significantly affects the consumption shares of the products being examined. More specifically, the greater are the marketing and segregation costs, the greater is the price increase of the non-GM labeled product (relative to the price of the product prior to genetic modification, p_t), and the lower is the utility associated with the unit consumption of the non-GM labeled product, $U_t^{'}$. For

[6] The segregation costs are higher for producers of the traditional product due to the effort required in preserving the identity of their produce by keeping it separate from the (inferior regarded) genetically modified one.

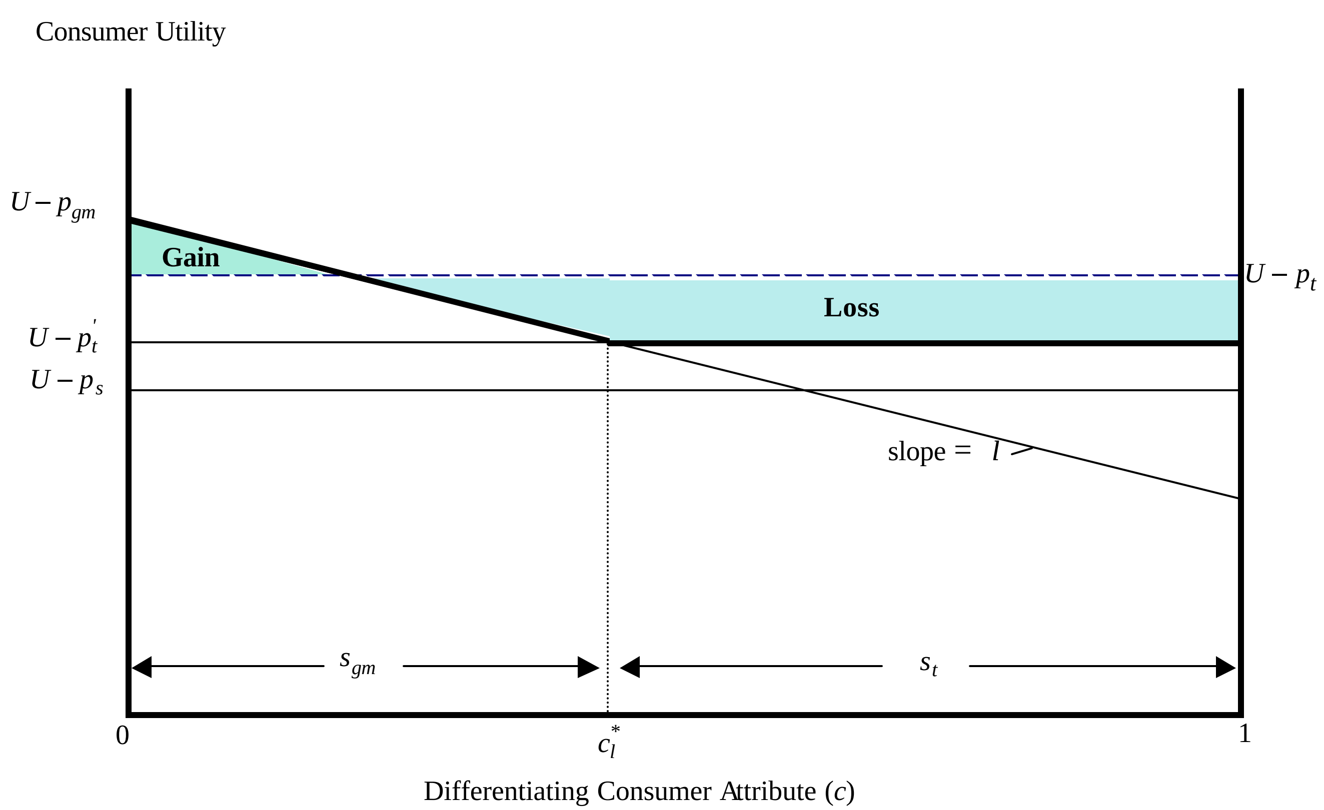
relatively high marketing and segregation costs, the utility from consuming the non-GM labeled product might fall below the utility associated with the consumption of the substitute (i.e. $U - p_t^{'} < U - p_s$). In such a case, consumers with a relatively high aversion to GM products will switch to the substitute product – there is no market demand for the traditional (non-GM) product.

Figure 4 depicts the consumption decisions under mandatory labeling when marketing and segregation costs are relatively low (i.e. when $U - p_t^{'} > U - p_s$). In this case, no consumer switches to the substitute. The consumption shares of the GM and non-GM labeled products are determined by the intersection of the U_{gm} and $U_t^{'}$ utility curves. The consumer with aversion to genetic modification given by:

$$c_l^* : U - p_{gm} - l c_l^* = U - p_t^{'} \Rightarrow c_l^* = \frac{p_t^{'} - p_{gm}}{l}$$

is indifferent between consuming a unit of GM and non-GM labeled product – the utility associated with the consumption of these offerings is the same. Obviously, consumers with low aversion to genetic modification (i.e. consumers with $c \in [0, c_l^*)$) prefer the GM product while consumers with high aversion to GM products (i.e. consumers with $c \in (c_l^*, 1]$) consume the non-GM labeled product.

Figure 4 Consumption Decisions and Welfare Effects when Segregation Costs are Relatively Low ($U - p_t' > U - p_s$) and $p_{gm} < p_t$



When consumers are uniformly distributed between the polar values of c, c_l^* also determines the share of the GM product to total consumption, s_{gm}. The consumption share of the non-GM labeled product, s_t, is given by 1-c_l^*, i.e.,

$$s_{gm} = \frac{p_t' - p_{gm}}{l} \left(= c_l^*\right) \text{ and}$$

$$s_t = 1 - \frac{p_t' - p_{gm}}{l}$$

Obviously, the share of the GM labeled product falls with an increase in its price and/or the utility discount factor and increases with an increase in the price of the non-GM labeled product (i.e., $\frac{\partial s_{gm}}{\partial p_{gm}} < 0$, $\frac{\partial s_{gm}}{\partial \lambda} < 0$, and $\frac{\partial s_{gm}}{\partial p_t'} > 0$).

When the transaction costs from mandatory labeling are relatively high (i.e. when $U - p_t' < U - p_s$), a portion of consumers switch to the substitute product. The consumption shares of the GM product and the substitute product are determined by the intersection of the U_{gm} and U_s curves in Figure 5 and can be written as:

$$s_{gm} = \frac{p_s - p_{gm}}{\lambda} \left(= c_\lambda^*\right) \text{ and}$$

$$s_s = 1 - \frac{p_s - p_{gm}}{\lambda}$$

Similar to the case of smaller marketing and segregation costs examined above, s_{gm} falls with an increase in p_{gm} and/or λ and increases with an increase in p_s (i.e. $\frac{\partial s_{gm}}{\partial p_{gm}} < 0$, $\frac{\partial s_{gm}}{\partial \lambda} < 0$, and $\frac{\partial s_{gm}}{\partial p_s} > 0$).

The welfare effects of genetic modification under mandatory labeling clearly depend on the effect of GM technology on the price of the GM product. More specifically, if the price of the GM product is less than the price of the product prior to its genetic modification (i.e. if $p_{gm} < p_t$) consumers with relatively low aversion to genetic modification will gain from the new technology. Consumers with relatively high aversion to GM product experience a reduction in their welfare due to: (i) the utility discount from

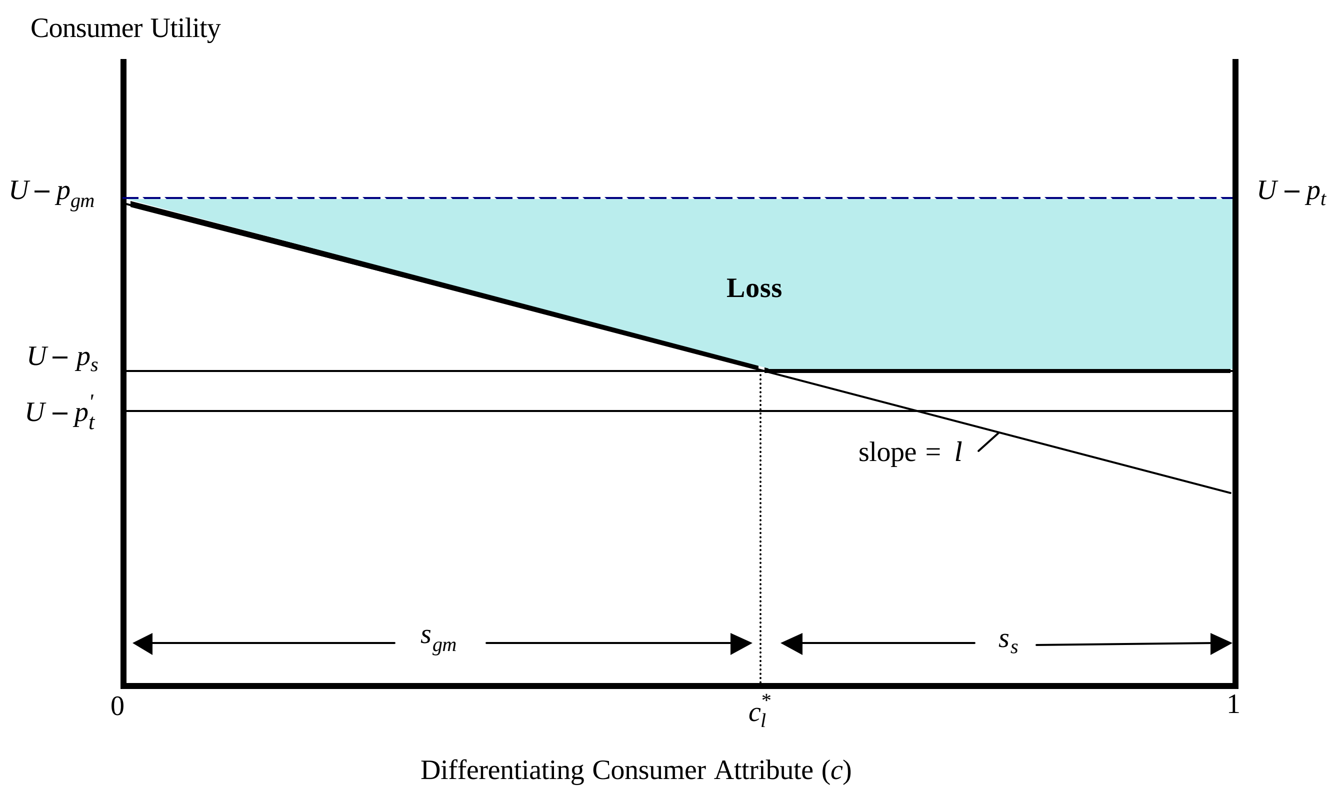
GM consumption; and (ii) the price increase of the traditional product caused by the marketing and segregation costs. Note that for p_{gm} to be reduced relative to p_t, two conditions should be met. First, the market structure must be such that production costs savings from the GM technology are transferred to consumers and, second, the price effect of the reduced production costs should outweigh the effect of increased transaction costs associated with mandatory labeling on the market price of the GM product.

Figure 4 graphs the effect of genetic modification on consumer welfare when marketing costs are relatively low (i.e. $U - p_t^{'} > U - p_s$) and $p_{gm} < p_t$. The dashed $U - p_t$ curve is the utility curve prior to genetic modification. For net consumer gains to be realized it should hold that: (i) the price decrease from genetic modification is relatively high, (ii) the discount in utility from consuming the GM product is relatively low, and/or (iii) the marketing and segregation costs are relatively low. A bunching of consumers at the left-hand edge or the right-hand edge of the diagram would increase the gain or loss, respectively.

More specifically, the greater is the price reduction from genetic modification, the greater is the upward shift of the U_{gm} curve, the greater are the consumer gains and the lower is the welfare loss from the new technology. Similarly, the lower is l, the greater is the slope of the U_{gm} curve, the greater are the gains and the lower are the consumer losses from genetic modification. Finally, the greater are the marketing and segregation costs incurred in the non-GM product chain, the greater is the downward shift of the $U - p_t^{'}$ curve and the greater are the consumer welfare losses from the new technology.

Figure 5 depicts the welfare effects of genetic modification when the transaction costs from mandatory labeling are relatively high (i.e. when $U - p_t' < U - p_s$) and $p_{gm} \geq p_t$. In this case, there are no consumers gaining from the new technology. The extent of the realized welfare losses depends on the level of aversion to genetic modification c, the utility discount factor l, and the level of p_{gm}.

Figure 5. Consumption Decisions and Welfare Effects when Segregation Costs are Relatively High ($U - p_t' < U - p_s$) and $p_{gm} \geq p_t$



5. CONSUMER BEHAVIOR UNDER MANDATORY LABELING: THE EFFECT OF MISLABELING

This section of the paper analyzes the consequences of mislabeling on consumer purchasing decisions and welfare. Mislabeling refers to the case where producers or processors misrepresent the type of the product sold in the market; they label GM products as non-GM in an attempt to capture the price premium paid for traditional (non-GM) produce.

When incidents of mislabeling occur in the food marketing system, consumer trust in labeling falls. Consumers can be expected to assign a probability to the event that what is labeled "non-GM" product is in fact genetically modified. Because of the uncertainty regarding the nature of the product consumed, the utility derived from the consumption of non-GM labeled product, U_t^m, equals $\theta[U - p_t' - \lambda c] + (1-\theta)[U - p_t']$ where θ is the likelihood that the non-GM label is false and the product is actually genetically modified.[7]

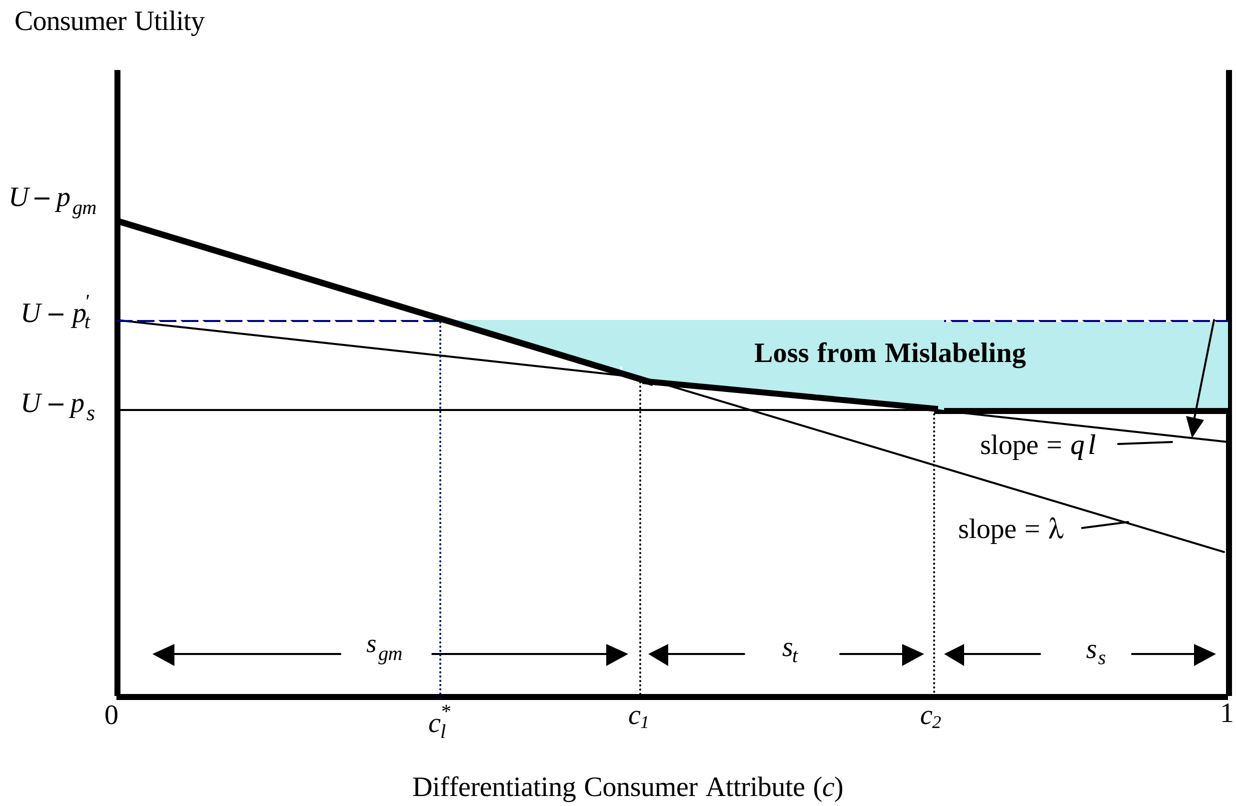
Taking into account this uncertainty, the consumer utility under mislabeling becomes:

$U_t^m = U - p_t' - \theta \lambda c$	if a unit of non-GM labeled product is consumed
$U_{gm} = U - p_{gm} - \lambda c$	if a unit of GM labeled product is consumed
$U_s = U - p_s$	if a unit of a substitute product is consumed

[7] Note that the consumer utility when the non-GM labeled product is GM is given by $U - p_t' - \lambda c$ (rather than $U - p_{gm} - \lambda c$) since the price paid for the consumption of the product is p_t' (and not p_{gm}).

Relative to the situation of full compliance examined in the previous section, product misrepresentation results in a discount in the utility associated with the consumption of the non-GM labeled product. Graphically, this utility discount can be seen as a clockwise rotation of the utility curve associated with the non-GM labeled product through the intercept at $U - p_t^{'}$ in Figures 5 and 6.

Figure 6 Consumption and Welfare Effects of Mislabeling when Segregation Costs are Relatively Low ($U - p_t^{'} > U - p_s$)



Consider first the case where marketing and segregation costs are relatively low (i.e. $U - p_t^{'} > U - p_s$). Compared to the case where mislabeling does not occur, mislabeling reduces both consumer welfare (shaded area in Figure 6) and the consumption share of the non-GM labeled product. A portion of the (previously) non-GM labeled product consumers (i.e. those with $c \in (c_l^*, c_1]$) switch to the GM labeled product while consumers with relatively high level of c (i.e. consumers with $c \in (c_2, 1]$) switch to the substitute. The greater is the probability θ that the non-GM label is false and/or the greater is the utility discount from the consumption of GM products, λ, the greater are the welfare losses from mislabeling and the greater is the share of non-GM consumers that switches to GM product and the substitute.

In the presence of mislabeling, the consumption share of the GM labeled product, s_{gm}, equals c_1, the share of the non-GM labeled product, s_t, equals c_2-c_1, while 1-c_2 percent of consumption moves to the substitute. Mathematically, the consumption shares can be written as:

$$s_{gm} = \frac{p_t^{'} - p_{gm}}{\lambda(1-\theta)} \quad (= c_1)$$

$$s_t = \frac{p_s - p_t^{'}}{\theta\lambda} - \frac{p_t^{'} - p_{gm}}{\lambda(1-\theta)} \quad (= c_2 - c_1)$$

$$s_s = 1 - \frac{p_s - p_t^{'}}{\theta\lambda} \quad (= 1 - c_2)$$

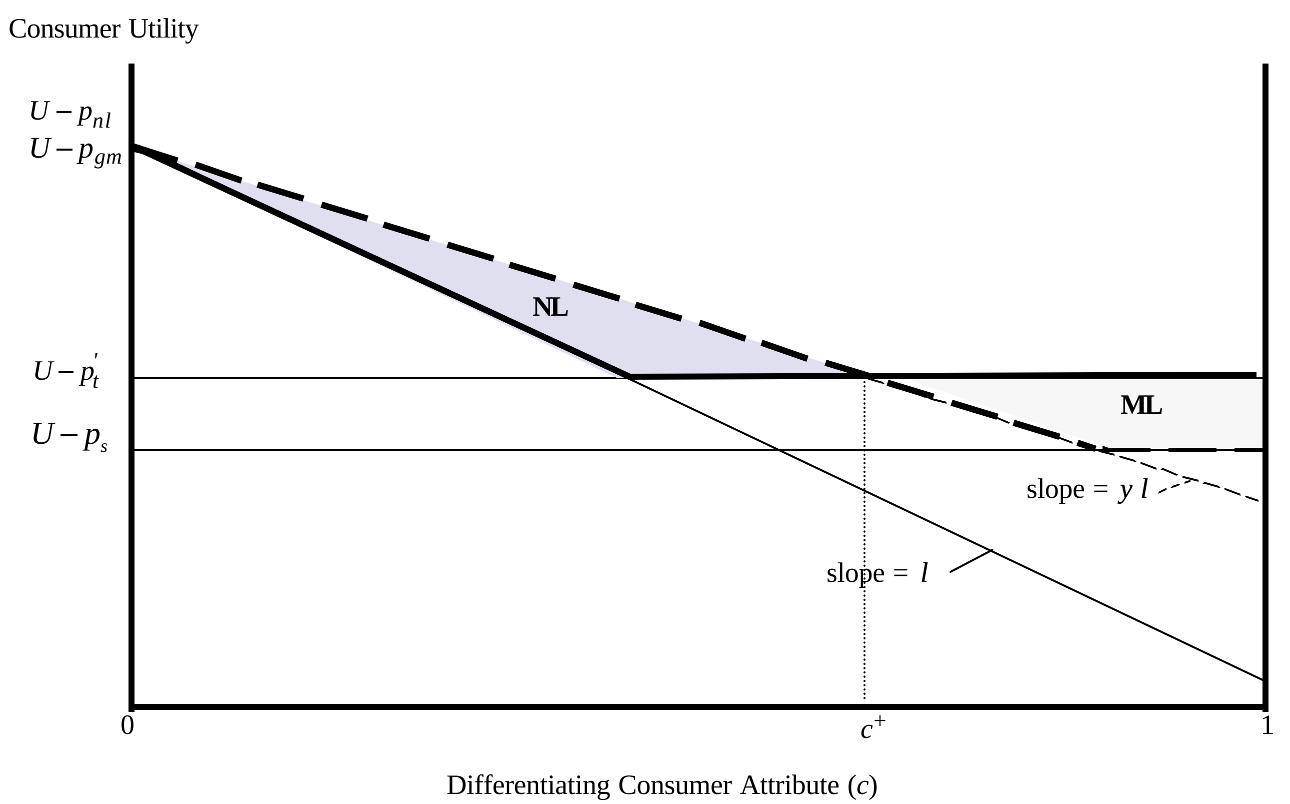
When the marketing and segregation costs are relatively high (i.e. when $U - p_t^{'} < U - p_s$), then mislabeling–as opposed to full compliance-has no effect on either the welfare or the consumption decisions of consumers since in this case no traditional (non-GM) product is consumed (see Figure 5).

6. NO LABELING VERSUS MANDATORY LABELING

After having analyzed the consumption effects of genetic modification under the "no labeling" and the "mandatory labeling" regimes, the question that naturally arises is which labeling regime dominates in terms of its effect on consumer welfare. Or, put in a different way, since the introduction of GM products can result in net welfare losses under both the "no labeling" and the "mandatory labeling" regimes, what is the labeling regime that harms consumers the least?

The determination of the factors affecting the relative performance of the two labeling regimes is straightforward. Figure 7 shows the effective utility curves under no labeling (dashed kinked curve) and mandatory labeling under full compliance when the

Figure 7 Mandatory Labeling vs. No Labeling when Segregation Costs are Relatively Low ($U - p_t' > U - p_s$)



marketing and segregation costs are relatively low (solid kinked curve). For simplicity and without loss of generality the figure depicts the situation where the price of the non-labeled product p_{nl} equals the price of the GM labeled product p_{gm}.

The shaded area NL reflects consumer utility under the no labeling regime that is lost when mandatory labeling is introduced. Similarly, the area ML represents consumer utility that is lost from a switch from mandatory labeling to no labeling. Obviously, consumers located to the right of c^+ will favor mandatory labeling, while for consumers located to the left of c^+ no labeling is the preferred labeling regime. The ranking of the labeling regimes in terms of their net effect on consumer welfare depends on the relative size of the shaded areas in Figure 7; if NL is greater than ML, then no labeling is the superior labeling regime. Obviously, when the assumption of a uniform distribution of consumers is relaxed, the welfare ranking of the two labeling regimes is affected by the skewness of the distribution. In general, the greater is the number of consumers that are characterized by a relatively high aversion to GM products (i.e. the more skewed towards one is the distribution of consumers with respect to their value of c), the greater is the likelihood that mandatory labeling is the preferred labeling regime.

Comparative statics results can easily be derived from Figure 7. For instance, an increase in the likelihood that the non-labeled product is GM (i.e. an increase in y) causes a clockwise rotation of the U_{nl} curve ($U_{nl} = U - p_{nl} - y\,lc$) that increases ML and reduces NL. The greater is y, the greater is the consumer support for mandatory labeling. Similarly, an increase in the marketing and segregation costs associated with mandatory labeling will shift the $U - p_t^{'}$ and $U - p_{gm} - lc$ curves downward increasing NL and reducing ML. The greater are the marketing and segregation costs, the greater is the proportion of consumers favoring no labeling; when marketing and segregation costs are relatively high (i.e. when $U - p_t' < U - p_s$) the area ML vanishes and no labeling is the superior labeling regime.

Finally, when the assumption of full compliance is relaxed and the possibility of product misrepresentation is introduced, the mandatory labeling regime becomes even less appealing from the consumers' standpoint; mislabeling increases the likelihood that no labeling is superior in terms of its effects on total consumer welfare. The greater is the probability that mislabeling occurs, the greater are the consumer utility losses under mandatory labeling, and the greater is the likelihood that an all-or-nothing choice among the two labeling regimes in terms of their effect on consumer utility will favor no labeling.

7. CONCLUDING REMARKS

This paper develops a model of differentiated consumers to examine the effects of genetic modification on the welfare and purchasing behavior of consumers. The conclusion of this paper is that if consumers perceive GM foods to be different from their traditional counterparts, then demands for the banning of GM products and GM labeling are rational. For instance, when the existence of market imperfections in one or more stages of the supply chain prevents the transmission of the cost savings associated with the GM technology to consumers, then the introduction of GM foods will generally result in welfare losses for consumers. This is true no matter the labeling regime that is in place.

Given that GM foods have been introduced into the food system, the analysis also shows that the relative welfare ranking of the "no labeling" and "mandatory labeling" regimes depends on: (i) the level of consumer aversion to genetic modification, (ii) the segregation costs associated with mandatory labeling; (iii) the share of the GM product to total production; and (iv) the extent of mislabeling. More specifically, the greater are segregation costs associated with mandatory labeling, the greater is the likelihood that no labeling is the superior labeling regime. The greater is the likelihood that the non-labeled product is GM, the greater is the likelihood that mandatory labeling will be preferred.

Finally, when the possibility of product mislabeling is introduced into the analysis, the desirability of mandatory labeling by consumers falls. The uncertainty about product characteristics due to mislabeling reduces consumer welfare and drives part of non-GM product consumers out of the market. The lower is the level of trust in the labeling system, the greater is the expectation that mislabeling occurs, the greater are the consumer utility losses under mandatory labeling, and the greater is the likelihood that an all-or-nothing choice among the two labeling regimes in terms of their welfare implications favors no labeling.

The results of this paper can provide an explanation of policy decisions about genetic modification and labeling observed around the world. Relatively low (or zero) consumer aversion to genetic engineering coupled with a reduced price of GM foods and significant segregation costs associated with mandatory labeling could be among the reasons why a “no labeling” policy has been adopted by countries like the United States and Canada. Increasing consumer concerns, however, and the relatively high level of consumer trust in the food safety institutions in both countries could increase the relative efficiency of – and hence the consumer demand for – mandatory labeling.

A relatively high aversion to genetic modification coupled with a lack of a price reduction for GM foods would rationalize mandatory labeling, an outcome seen in various EU countries. However, a high level of distrust of food safety and inspection systems can undermine the value of labeling. This result sheds light on the demand for an outright ban of GM products by some European consumers, since faith in the food inspection system there has been reduced because of food safety scares such as the Bovine Spongiform Encephalopathy crisis in the British beef industry.

In summary, consumer concerns about GM products can be expected to affect consumption decisions and to influence the public policy response demanded by consumers. These consumption decisions, along with the decisions made by policy makers as to how GM products are introduced into the food system, can have significant impacts on the demand for GM products throughout the food system. These system effects, in turn, will affect the decisions made by farmers as to which crops they grow and decisions by life science companies as to the pricing of the GM technology and the development of new technologies.

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