What labelling policy for consumer choice? The case of genetically modified food in Canada and Europe

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**Abstract.** Faced with divergent opinions among consumers on the use of genetically modified (GM) foods, Canada has adopted a voluntary labelling approach for non-GM foods, whereas the European Union has a mandatory labelling policy for GM foods. Interestingly, both labelling systems have resulted in very little, if any, additional consumer choice. Using an analytical model, we show that the coexistence of GM and non-GM products at the retail level depends on the labelling policy, consumer perceptions, and the type of product. Although voluntary labelling tends to favour the use of GM products, it is more likely to provide consumer choice. JEL classification: L15, Q18

1. Introduction

The labelling of genetically modified (GM) foods is at the centre of the international controversy over bioengineered crops. Some countries (e.g., countries of

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the European Union (EU) and Japan) require mandatory labelling of food products containing GM ingredients, whereas other countries have chosen to adopt a voluntary labelling policy for non-GM products (e.g., Canada and the United States). Countries that have chosen mandatory labelling maintain that this policy provides consumer information and lets the consumer choose. Environmental and consumer groups supporting mandatory labelling argue that uncertain effects of this new technology create potential risks for human health and the environment and that consumers should be able to choose what they eat. Some scientists have denounced labelling policies, because, they argue, GM and non-GM food products are virtually the same from a nutritional standpoint, and they present the same food safety risks (McHughen 2000). According to this view, mandatory labelling is objectionable because it sends a signal that GM food may be undesirable. The North American food industry views the EU labelling policy as disguised protectionism.

Past economic studies have compared the effects of voluntary and mandatory information disclosure on product quality in the presence of information asymmetry. A key result of the literature is that, assuming that all revealed information is truthful, a monopolistic firm will voluntarily disclose product quality when it is costless to do so (Grossman 1981; Milgrom 1981). In the same setting, but assuming costly signalling, Jovanovic (1982) further demonstrates that voluntary disclosure will result in a socially excessive amount of information, and therefore mandatory disclosure will only be harmful. But voluntary disclosure is not always found to be better than mandatory disclosure. Other authors have studied cases where the seller has the option to acquire information on the quality (via costless testing; see Matthew and Postlewaite 1985) or on the value of their product (via costly assessment; e.g., Shavell 1994), and their analyses diverge on the optimality of the two types of disclosure options. Moreover, Board (2003) showed that under costless disclosure, competition may reduce the amount of information available in a voluntary system, and his conclusions suggest that mandatory disclosure can promote competition and efficiency.

Previous research on the economics of labelling has also discussed the conditions under which labelling policies are beneficial (Crespi and Marette 2003). Nelson (1970) and Darby and Karni (1973) categorized goods into three groups: search goods, experience goods, and credence goods. In the case of search goods, consumers can determine the quality of the good before they buy it, so there is no information asymmetry. For experience goods, consumers first need to buy and consume the good in order to evaluate its quality. Experience goods present an informational problem, but it can be solved by repetitive purchases of the same good. For credence goods, consumers cannot determine the quality of the product even after consumption. According to Caswell and Mojuszka (1996), a label is one way to transform experience and credence attributes of a product into search attributes. Policy makers may therefore use labels to try to correct the presence of imperfect information, to lower transactions costs, or to correct
externalities. However, Magat and Viscusi (1992) argue that labelling is an ineffective policy if consumers are not interested in the information on the labels or do not read the labels. Weil et al. (2006) argue that a regulatory disclosure policy (such as mandatory labelling) will be effective only if it is embedded into the everyday decision-making routines of users and disclosers; otherwise, it should not be used. Furthermore, Golan, Kuchler, and Mitchell (2001) argue that in many cases mandatory labelling is not the first-best policy to reduce externalities or correct asymmetric information.

In the case of GM food labelling, there is a wide range of international policies, with different effects in terms of consumer choice (Carter and Gruere 2003). Using analytical models, the existing literature has derived welfare effects of labelling (Kirchoff and Zago 2001; Giannakas and Fulton 2002; Crespi and Marette 2003; Fulton and Giannakas 2004; Hobbs and Kerr 2006). Kirchoff and Zago (2001) show with a simple model that the status quo labelling policies in the EU and in the United States correspond to the best interests of producers, consumers, and activists in these countries. Giannakas and Fulton (2002) use a model of heterogeneous consumers to show the welfare benefits associated with labelling and the effects of mislabelling. Crespi and Marette (2003) use a model of consumer demand with information asymmetry to show that the optimal labelling policy (positive versus negative labelling) should account for the relative consumer acceptance of GM food, and thus the EU policy may not be due to strategic trade policy. Fulton and Giannakas (2004) provide an analytical model of consumers, farmers, and life science companies to compare the welfare effects of mandatory labelling, no labelling, and no GM at all. They find that consumers, farmers, and life science companies will never agree on which labelling policy is the best.

More recently, in their analysis of labelling and international trade, Hobbs and Kerr (2006) demonstrate with a partial equilibrium trade model that mandatory labelling will always be a superior policy to an embargo. At the same time, Hobbs and Kerr also argue that there is an exception to the rule in corner solution cases where labelling acts as a hazard warning signal, and consumer rejection results in the disappearance of the labelled product. Interestingly, this exception essentially represents the observed outcome of GM food labelling requirements in developed countries.

Interestingly, all these previous studies implicitly assume that the consumer is ultimately presented with a choice between GM and non-GM labelled food. Yet mandatory labelling in the European Union (EU) has resulted in the virtual disappearance of any GM-labelled product, so in practice EU consumers do not have a choice when they go shopping (Kalaitzandonakes and Bijman 2003).
In the EU, food retailers decided to avoid selling GM products as a marketing strategy, and food processors shifted ingredients away from any GM material. A similar development took place in Japan and Australia, where there are mandatory labelling requirements on certain products. On the other hand, in countries with voluntary labelling, such as Canada, until recently it was rare to find non-GM labels on products, but organic products provide consumers with a non-GM choice (Gruère 2006).

In this paper, we study the economic effects of introducing two alternative labelling policies by focusing on their impacts on consumer choice. We show why mandatory labelling of GM foods tends to encourage processors to avoid labelling in the EU, and why this policy is more likely to result in sustainable corner solutions, compared with voluntary labelling. We find that differences in GM versus non-GM prices and costs matter as much as consumer perceptions in determining whether or not consumers will have a choice. We also find that the type of product affects the outcome in terms of consumer choice. By focusing on the differences between the two types of labelling policy and their effects on consumer choice, we do not address the question of the benefit of labelling compared with no labelling, which has been addressed in other studies. In addition, we limit ourselves to products belonging to the so-called first generation of GM crops, which offer a cost reduction to agricultural producers, but have no direct nutritional benefit to consumers, except for a possible price discount.

Our paper extends the existing literature on labelling by introducing the important role of market intermediaries – in our case, food processors and retailers. Labelling regulations first impact food processors. Based on their information, the regulations, and the market pressures they perceive, processors will decide whether to label or to change ingredients in order to avoid labelling. Naturally, their choice will depend indirectly on consumers’ likely acceptance of GM products, so there is a notion of consumer choice ex ante, but under mandatory labelling it may disappear ex post.

Our paper extends the economic literature by providing an original case study of product quality information disclosure with endogenous quality and by using it to compare voluntary and mandatory disclosure approaches. A notable limitation in the main theoretical papers on information disclosure (including those cited above) is that they all assume that product quality is exogenous, in order to focus on the effect of various disclosure strategies. Similarly, empirical studies that focus on the observed effects of disclosure policy on consumer choice also

3 Note that our definition of consumer choice differs from that in other studies; instead of focusing on the effects of labelling on consumers’ demand for alternative products, we focus on the effect of labelling on the choice of products available to consumers.

4 In what follows, all that applies to processors also applies to retailers in their choice of products to carry in their stores. In the EU, large retailers have decided not to carry any product labelled as containing GM ingredients.
tend to assume that sellers do not change their products with the introduction of labelling (e.g., Mathios 2000).

Our three-stage conceptual approach is represented in figure 1. First, the regulator chooses the labelling policy; second, the processor will decide whether or not to produce food that requires a label; and third, the consumer may or may not have a choice. We analyze the third stage first, where the consumer chooses her consumption bundle. For different types of consumers, we evaluate how the demand for a product is affected at the margin by a label and we consider the consequences of no choice. The second stage is set at the processor level. The processors are assumed to be perfectly informed about any change in consumer demand, for a given change in product quality. They know the cost of producing GM versus non-GM food and the labelling costs, and they decide to either produce GM food products or not. Comparing the case of a voluntary label with that of a mandatory label, 5 we derive the conditions influencing the processors’ choice between labelling and not labelling under two cost structures, constant and increasing marginal cost of production. We then close the model by linking the decision of processors to the long-term market outcome in terms of consumer choice and reach some conclusions on the implications of policy choice regarding labelling.

2. Information and labels: effects of different labelling policies

Throughout our analysis, we assume that, from the perspective of market intermediaries, and before they make their decision to label or not (see figure 1), labelling is expected to have a non-zero effect on consumer demand. A number of studies have provided evidence of the effects of food labelling on consumer demand. For example, using a panel of scanner data based on consumer actual purchases in supermarkets, Mathios (2000) demonstrates that the introduction of mandatory labelling applies only to GM products, and does not require the labelling of non-GM products, whereas voluntary labelling only applies to non-GM products.

5 Currently, mandatory labelling applies only to GM products, and does not require the labelling of non-GM products, whereas voluntary labelling only applies to non-GM products.
nutritional labelling in the United States changed consumer demand on salad dressings. Similarly, Kiesel, Buschena, and Smith’s (2005) analysis of scanner data shows that voluntary labelling of milk not produced with RBst growth hormones affected consumer demand for different types of fluid milk in the United States.

Our assumption is also consistent with the results of a survey European food company (Knight, Mather, and Holdsworth 2005) on the use of GM ingredients. Still, in the case of the European Union, we should note that two studies question the visibility and ability of consumers to read GM food labels. The first study, based on an experiment with isolated French consumers, shows that they would not read the GM label unless asked to do so (Noussair, Robin, and Ruffieux 2002). The second study using scanner data on purchases of frozen pizza in the Netherlands, during the short period when some GM-labelled products were sold in supermarkets, shows that there was no significant decline in demand of GM-labelled products (Marks, Kalaitzandonakes, and Vickner 2004). Nevertheless, even if European consumers did not read labels (assuming labelled goods were present again on the retail shelves), it is clear that in the current context of scrutiny and activist campaigns targeting any potential GM product, consumers would ultimately be aware of GM food labels. From the perspective of processors, it is therefore reasonable to assume that consumer acceptance will matter in labelling choices.

2.1. Consumer effects

In this section, we separate out the effects of labelling policies on trusting consumers from the effects on distrusting consumers. Distrusting consumers are guarded in their food purchases. This group includes mothers of young children avoiding any potential food safety risk, or European consumers who have faced recent food scares (such as the Bovine Spongiform Encephalopathy (BSE) crisis that hit Europe) and do not completely trust their own government’s food safety regulations. Some of these consumers may be indifferent to the GM issue, given the information they have. Others may be opposed to GM, as they implicitly follow the precautionary principle approach for their own consumption. In addition they may be opposed because of concerns over the environmental effects of GM or other reasons. Trusting consumers have faith in their government in the matter of food safety and they perceive quality change through reading labels. Trusting consumers believe that any significant risk will be spelled out on the label. Many Canadian consumers are included in this group, as they generally trust the Canadian food safety authority. In fact, most of these consumers do not know the regulatory details, but they assume that the government would not allow the sale of unsafe food. Some of the trusting consumers may be opposed to GM food, but do not perceive any product difference if there is no label. Others will be indifferent to consuming GM food.

To understand the effects of alternative labelling policies on consumers, we build on the framework provided by Giannakas and Fulton (2002). They model
consumers by adapting the classical vertical differentiation model of Mussa and Rosen (1978), as presented in Tirole (1988). Our model starts with the following indirect utility $V_{ij}$ of an individual $j$ for variant $I = g,n$ (GM or non-GM):

$$
V_{ij} = a - p_i + \Psi_i(\lambda)(1 - \tau)\theta_j, \quad (1)
$$

where $a$ is the basic utility from consuming the good, $p_i$ is the price of variant $i$ (GM or non-GM) and the expression $\Psi_i(\lambda)(1 - \tau)\theta_j$ represents the utility shifter (or willingness to pay) for the quality component of the product. The function $\Psi_i(\lambda)$ stands for the overall perception of the quality of the product, and it is the same across all consumers in a given country. This function will be linear in $\lambda$, where $\lambda$ can be interpreted as the maximum willingness to pay for the absence of GM. The maximum willingness to pay for non-GM food is equal to $a + \lambda$. The quality component captures the perception of both human health effects and the environmental impacts of food production. The parameter $\tau$ represents the threshold level associated with the label. It is fixed by the regulator in each country. Threshold levels vary from the mandatory 0.9% in the EU to 5% for the voluntary guidelines in Canada or the mandatory labelling policy in Japan. We assume that the consumer has a lower utility from a higher threshold level.\footnote{We could ignore the threshold level. In fact, countries do not report their threshold on the labels, so trusting consumers do not necessarily know the threshold level. It is also the case that some products do not even have to be labelled in the EU (e.g., meat), even if they are produced with GM ingredients.}

Finally, $\theta_j$ is the idiosyncratic consumer preference, and we normalize it to the interval [0,1]. It represents the taste parameter of each consumer $j$ in the population. Consumers with $\theta_j = 0$ are indifferent to the GM/non-GM quality dimension, and consumers with $\theta_j = 1$ are anti-GM. For simplicity, we use a uniform distribution of tastes.\footnote{Giannakas and Fulton (2002) show that this model can be easily extended to alternative distributions of taste. In the welfare analysis below, we differentiate trusting from distrusting consumers.}

The parameters $a$, $\lambda$, $\tau$, and $\theta$ are exogenous in our model. Prices are exogenous for consumers.

We calibrate the quality expression $\Psi_i(\lambda)$ using a perceived quality function as shown in table 1. For distrusting consumers, $\Psi_i(\lambda) = \lambda > 0$ for the non-GM variant and $\Psi_i(\lambda) = -\lambda$ for the GM variant. This assumption reflects the results of international surveys, where positive willingness to pay is observed for non-GM (Moon and Balasubramanian 2001, 2003; McCluskey et al. 2003; Chern et al. 2003; Lusk, Roos, and Fox 2003; Hu, Veeman, and Adamowicz 2005). This also reflects the results from experimental economic studies showing that consumers’ willingness to pay for food decreases when they find a GM label (Tegene et al. 2003; Noussair, Robin, and Ruffieux 2004) because the label is a negative signal.

In contrast, the trusting consumers make an informed choice according to the label, as shown in table 1.\footnote{We will assume that they trust the label, and that mislabelling does not occur. For the case of mislabelling see Giannakas and Fulton (2002).} Goods without labels under any labelling regime...
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TABLE 1
Quality function $\Psi_i(\lambda)$ for trusting and distrusting consumers

<table>
<thead>
<tr>
<th>Type of consumer Labelling policy/product</th>
<th>Trusting</th>
<th>Distrusting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary (GM free)</td>
<td>$0$</td>
<td>$-\lambda$</td>
</tr>
<tr>
<td>Mandatory (contains GM)</td>
<td>$-\lambda$</td>
<td>$0$</td>
</tr>
</tbody>
</table>

are perceived as conventional by trusting consumers. Alternatively, a GM label is perceived as a negative signal of quality and a non-GM label is perceived as a positive-quality signal.

Both the trusting and distrusting consumer groups include some individuals indifferent to the GM/non-GM food issue. A consumer may be trusting or distrusting, but still be indifferent to GM for scientific reasons or because she is more sensitive to price or other attributes such as quality.

The cost structure of the two labelling policies differs. Both labelling systems require companies in the food chain to set up a documentation system for the targeted labelled attribute. In addition, mandatory labelling requires public enforcement costs, whereas voluntary labelling requires private identity preservation systems with an incremental cost relative to mandatory labelling. To simplify our analysis we focus on the main differences in cost structure between the two regimes.\(^9\) We assume that mandatory labelling is financed publicly by a tax per consumer $T$, and that third-party certification for voluntary labelling is financed as a per unit fee $C$ included in the cost of production. Currently, under voluntary labelling, processors willing to label their product as non-GM must guarantee their claim, which requires setting up a tracking system for input sources. This generates a cost that is transmitted to the consumers. In contrast, mandatory labelling (as in the EU) requires frequent inspections of the traceability systems at processing firms and retailers, as well as testing at different levels in the agri-food chain to enforce the labelling regulation. Prices will be denoted as $p_g$ for the GM good, $p_n$ for the non-GM good under the mandatory labelling regime, and $p_n^*$ for the non-GM good under voluntary labelling.

We consider two main examples: the Canadian and the EU labelling policies, cases that adequately summarize the range of international labelling policies.\(^10\) These two alternative approaches are shown in table 2.

We first present our analytical results in graphical form. In figure 2, we show the case of the EU mandatory labelling policy. The vertical axis is the level of utility, and the horizontal axis represents the distribution of consumers according to

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\(^9\) In other words, since we are interested in comparing the two regimes, we set the basic or non-specific private labelling cost for the two labelling policies equal to zero.

\(^10\) The policy of the United States is almost identical to that of Canada, but because the U.S. policy is only a draft guideline, we focus our study on the Canadian labelling policy formally in place since 2004.
TABLE 2  
Current GM food labelling policies in the EU and Canada

<table>
<thead>
<tr>
<th></th>
<th>European Union</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labelling policy</td>
<td>Mandatory labelling of GM at the 0.9% level of each ingredient</td>
<td>Voluntary non-GM labelling</td>
</tr>
<tr>
<td>Retail food products</td>
<td>Non-GM</td>
<td>GM (unlabelled) and non-GM</td>
</tr>
<tr>
<td>available</td>
<td></td>
<td>(mostly organic)</td>
</tr>
<tr>
<td>Crop production and</td>
<td>Produces mainly non-GM, and imports GM and non-GM</td>
<td>Produces and exports GM and</td>
</tr>
<tr>
<td>trade</td>
<td></td>
<td>non-GM</td>
</tr>
</tbody>
</table>

their taste parameter \( \theta \). Utility is linear in the individual parameter \( \theta_j \), as shown in equation (1). \( V_g \) represents the utility associated with consuming the GM product. Similarly, \( V_n \) represents the utility of consuming the non-GM product.

For EU consumers, we assume that the quality population parameter \( \lambda \) is large in absolute value because of the negative image of agricultural biotechnology in the EU. Thus, the slopes of \( V_g \) and \( V_n \) (in the left-hand panel of figure 2) are relatively steep compared with the Canadian case. For now, we assume that there is a price premium for non-GM products,\(^{11}\) because GM products would not be sold without a price discount. In the EU, some products with GM ingredients have briefly existed but then quickly disappeared (Kalaitzandonakes and Bijman 2003; Marks, Kalaitzandonakes, and Vickner 2004).\(^{12}\) Giannakas and Fulton (2002) argue that the price premium between non-GM and GM with mandatory labelling can be explained by the fact that most of the increased marketing and segregation costs will occur in the non-GM product chain.

Each consumer \( j \), with taste parameter \( \theta_j \), chooses the product that generates the highest utility, and so the higher utility lines (in bold in figure 2) represent the actual utility of the population of consumers. For each case, the intersection of the bold utility lines corresponds to the point where consumers are indifferent between purchasing GM and non-GM, with parameter \( \hat{\theta} \in \{ \theta_D, \theta_T \} \). To the left of this point (for \( j \) such that \( \theta_j \in [0, \hat{\theta}) \)), consumers will prefer to buy the GM good, and to the right of this point (for \( j \) such that \( \theta_j \in (\hat{\theta}, 1] \)) consumers will prefer to buy the non-GM good. For a uniform distribution of tastes \([0,1]\), the parameter \( \hat{\theta} \) also represents the share of consumers willing to buy the GM good, so the other share is \( 1 - \hat{\theta} \).

On the left-hand panel in figure 2, we represent the effects of the EU policy on distrusting consumers. This group of consumers values non-GM food as a quality attribute, and thus \( V_n \) is upward sloping with a slope equal to \( +\lambda (1 - \tau) \). Distrusting consumers in the EU perceive GM food negatively and thus their utility for the GM variant is represented by a downward sloping line \( V_g \), with a slope equal to \( -\lambda(1 - \tau) \) (corresponding to the expression in table 1). \( V_g \) varies

\(^{11}\) Prices become endogenous in section 2.3 below.
\(^{12}\) Surveys show that only a handful of GM-labelled products are on sale in European supermarkets (Food Production Daily 2004; Gruère 2006; GMO Compass 2007).
FIGURE 2 Consumer effects of the EU labelling policy

from \( a - p_g - T \) for consumers indifferent to GM (with \( \theta = 0 \)), paying price \( p_g \) and tax \( T \), to \( a - p_g - \lambda (1 - \tau) - T \) for consumers opposed to GM (with \( \theta = 1 \)), who pay the same price but have a disutility associated with consuming GM products. In this part of figure 2, the parameter \( \hat{\theta} \) is noted \( \theta_D \). In the EU, there are virtually no labelled GM products sold, so that the \( V_g \) line should be considered hypothetical; that is, its existence is conditional on the presence of GM products at the retail level. The fact that mandatory EU labelling resulted in the disappearance of GM products gives rise to welfare losses in terms of opportunity costs among the least sensitive distrusting consumers (with a relatively low \( \theta \)). This opportunity cost is represented as the shaded triangle in the left panel of figure 2. The size of the loss depends on the slopes of the utility curves and the price premium consumers must pay for non-GM products. It may be small, depending on the actual proportion of distrusting consumers who are somewhat indifferent to the GM quality dimension and whose preferences are dominated by prices.

On the right-hand panel in figure 2, we represent the case of trusting consumers in the EU. These consumers rely on labels, and they do not distinguish GM from non-GM products. There are no labels on non-GM, so the slope of \( V_n \) is zero, and \( \Psi_{ng}(\lambda) = 0 \) (see table 1). The loss to the trusting consumers from not having access to GM-labelled products (the shaded triangle in the right panel) is larger than the corresponding loss to the distrusting consumers (shown in the left panel). The share of trusting consumers who would choose GM (noted \( \theta_T \)) will always be larger than the corresponding proportion of distrusting consumers.\(^{13}\)

Overall, we find that the loss in consumer choice (shaded triangles in figure 2) resulting from the use of mandatory labelling in the EU is proportional to the

\(^{13}\) By symmetry, the share of trusting consumers in our case is twice as large as the corresponding share of precautionary consumers (because the slopes of \( V_n \) and \( V_g \) on the left-hand panel in figure 2 have the same absolute value \( \lambda(1 - \tau) \)).
price difference between GM and non-GM and will increase with the proportion of trusting consumers. The loss will be non-zero as long as the price difference is greater than zero. Noussair, Robin, and Ruffieux’s (2004) experimental study suggests that price-sensitive consumers may represent a substantial share of EU consumers, as 43% of their French experimental subjects were willing to buy GM food, provided the price was right.

In figure 3, we show the effects of the Canadian voluntary labelling policy. We use a smaller $\lambda$ in absolute value to represent the fact that in Canada there is relatively less consumer concern over GM food, compared with the EU. In Canada, the labelling policy is voluntary and it allows consumers to choose between GM and non-GM. Figure 3 shows that there may be a relatively large difference in GM market shares between trusting and distrusting consumers (compare $\theta_D$ and $\theta_T$). Compared with the EU policy, the aggregated share of consumers buying GM is larger, because of a larger price premium for non-GM food and a lower-quality parameter $\lambda$ in Canada. The Canadian policy results in no welfare loss related to consumer choice.

To conclude this section, we find the following:

**The consumer effects of each labelling policy depend on the type of consumers and their general concern towards GM food. In particular, as long as there is a price difference, indifferent and price sensitive consumers in countries like the EU will suffer a welfare loss, owing to lack of choice induced by labelling regulations.**

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14 Detailed derivations are available in an on-line appendix linked to this article at the CJE journal archive http://economics.ca/cje/archive.php.
15 The non-GM alternative in Canada is almost entirely represented by organic products, but there are some non-GM, non-organic, food products available and labelled as such.
2.2. Processor choice
Our model allows us to derive the expected demand for each variant under each labelling policy (mandatory and voluntary). First, we determine the threshold parameter $\hat{\theta}$ between the two variants, which corresponds to the utility of indifferent consumers. In the case of a uniform distribution of tastes, it will be equal to the share of consumers buying GM food. Secondly, we integrate the uniform cumulative density function over each interval of reference.

In the case of the EU, before the introduction of mandatory labelling, processing firms had to forecast the expected (or anticipated) share of the market unwilling to buy GM-labelled products. The indifferent trusting consumer will either purchase GM and enjoy utility $V_g = a - p_g - \lambda(1 - \tau)\hat{\theta} - T$ with a label, or purchase the non-GM, non-labelled product with utility $V_n = a - p_n - T$. Because she is indifferent, both these utilities are equal, and they determine the expected share of GM consumers (among trusting consumers): $S_g^{\text{trusting}} = \hat{\theta} = (p_n - p_g)/\lambda(1 - \tau)$ (the share of non-GM consumers is then equal to $1 - S_g^{\text{trusting}}$). We can use the same type of reasoning to derive the expected share of GM consumers among the distrusting consumers. Below, we assume that a share $\beta_2$ of the total population of consumers is distrusting.\textsuperscript{16} The remaining majority of consumers $\beta_1 = 1 - \beta_2$ are trusting. We find that the total expected market share of GM will be equal to $S_g = (\beta_1 + \beta_2/2)S_g^{\text{trusting}}$.

In our model, processors evaluate the expected consumer demand for GM or non-GM ex ante, and then choose which type of food to produce for a given labelling policy. Processors adapt to the specifics of the regulation. We will now present two models of processor decision making with alternative cost structures. First, we will present the simple case of processors with constant marginal costs, and second with increasing marginal costs of production.

2.2.1. Constant marginal costs of production
We do not consider fixed costs, so processors’ profit is equal to the average net revenue multiplied by the quantity produced. The quantity produced is obtained simply by multiplying the expected share of consumer purchases ($S_i$) by the current number of customers ($N$), so profits $\Pi^k_i$ of processor $k$ for variant $i$ is defined as $\Pi^k_i = (p_i - c^k_i)S_iN$, where $p_i$ is the price and $c^k_i$ the marginal cost of production for type $i = g,n$. The marginal cost of producing GM is $c^k_g$, and the marginal cost of producing non-GM is equal to $c^k_n$ and $\forall k, c^k_n > c^k_g$. In addition, for the voluntary labelling case, the cost of keeping ingredients segregated from conventional ingredients is $C$. The parameters $c^k_i$, $C$, $N$ are exogenous. The different profit functions are reported in the electronic appendix (see fn 14).

The processors will choose the largest profit between GM and non-GM, and labelled or not labelled. Their decision is based on expected demands and cost differences and is made in the short run, so that prices are exogenous.\textsuperscript{17} We focus

\textsuperscript{16} We assume that the population share of distrusting consumers $\beta_2$ is constant and exogenous.
\textsuperscript{17} Implicitly, by assuming that the processors use present prices to determine expected demand, we assume that processors are risk neutral and have naive supply expectations.
on the decision rule between producing with GM versus non-GM ingredients for each type of expected demand under the two labelling regimes.

Our results are presented in figure 4.\textsuperscript{18} This figure shows parameter values that determine whether GM is more profitable than non-GM. The horizontal axis corresponds to the expected (or anticipated) market share of the GM product (given prices, the threshold level $\tau$, and the taste parameter $\lambda$). For any processor, the expected market share $S_g$ represents the average probability of selling her product if she uses GM ingredients. The vertical axis measures the average profit ratio of non-GM to GM. The upward sloping curve is the break-even or isoprofit line, along which processors will be indifferent between producing GM or non-GM (e.g., at point Y). To the left of this curve (e.g., point X), the processor will adopt non-GM ingredients. To the right of this curve (e.g., point Z) processors will use GM ingredients.

Figure 4 is applicable for the introduction of either mandatory or voluntary labels; only the ratio of profits changes from $p_n - c_n^k/p_g - c_g^k$ for mandatory labelling to $p_{n}^* - c_n^k - C/p_g - c_g^k$ for voluntary labelling. However, because the non-GM price premium is different under each of the two labelling schemes, as are the costs of production, we can expect to see the voluntary labelling case to

\textsuperscript{18} The derivations are shown in the electronic appendix (see fn 14).
the right of the mandatory labelled case for each product. For example, if a firm’s decision variables are located at point X under a mandatory labelling regime, it will shift towards point Y under a voluntary labelling regime.

In this model, the cost of producing non-GM under voluntary labelling exceeds the cost of non-GM production under mandatory labelling because the processor incurs certification costs under voluntary labelling. Under mandatory labelling, the government pays the cost of labelling certification. Voluntary labelling involves an incremental certification cost per unit equal to $C$. This cost will raise the price gap between non-GM and GM, and this in turn will raise the expected market share of GM products (the equilibrium point will shift to the right). This extra cost may also change the non-GM to GM profit ratio. If this cost is fully transmitted to the product price, then the profit ratio will not change. If the cost $C$ is relatively large, the firms that are willing to stay in the market as non-GM processors will do so only if they can obtain a much higher premium (i.e., non-GM will become a niche market). Thus, a voluntary labelling policy increases the probability that processors will choose to produce GM.

For each country and for a given product, processors determine the expected share of the market they will supply as price takers. These expected market shares\textsuperscript{19} in the EU and Canada are represented by the vertical dashed segments in figure 4. On each vertical segment, different firms will have different costs according to their own characteristics and whether they are producing GM or non-GM. In a country were perceptions towards GM are negative and where there is mandatory labelling as in the EU, we expect to observe processors choosing to manufacture only non-GM products without labels. In a country where the price difference is more important (with voluntary labelling) and consumer perception is less negative, as in Canada, we expect to observe a large part of the industry choosing to produce GM.

We can use figure 4 to show the further results depicted in table 3. From any given point, it is possible to move a processor’s equilibrium down by increasing the profit of GM compared with non-GM, or to move them right by decreasing the quality perception parameter $\lambda$ or by increasing the threshold level $\tau$.\textsuperscript{20} Both these changes bring us closer to the GM area. If the non-GM to GM price difference increases, a given point (representing a processor) will move

\begin{table}
\centering
\caption{Marginal effects of various parameters on the location of a firm in figure 4}
\begin{tabular}{cccccccc}
\hline
Positive change in & $p_g$ & $p_n$ & $c_g$ & $c_n$ & $C$ & $\lambda$ & $\tau$ & $\beta_1$ & $\beta_2$ & From mandatory to voluntary \\
\hline
Movement in figure 4 & $\leftarrow$ & $\rightarrow$ & $\uparrow$ & $\downarrow$ & $\leftarrow$ & $\rightarrow$ & $\leftarrow$ & $\rightarrow$ & $\leftarrow$ & $\rightarrow$ or $\nearrow$
\end{tabular}
\end{table}

\textsuperscript{19} Note that the actual shares (ex post) are not represented on this figure.
\textsuperscript{20} As general quality is measured as $\lambda(1 - \tau)$. 
in the northeast direction, so it is not clear which type of product will then be produced.

Consequently, we have the following results:

Under mandatory labelling, the coexistence of GM and non-GM products at the retail level will be facilitated with a higher share of trusting consumers, a higher threshold level for adventitious presence of GM, and higher profitability of GM compared with non-GM. In contrast, under voluntary labelling, the coexistence of GM and non-GM is more likely in the market with a lower threshold level and a lower proportion of trusting consumers or if the profitability of non-GM is relatively large for some products. Mandatory (voluntary) labelling increases the likelihood that processors will choose non-GM (GM) ingredients, ceteris paribus.

2.2.2. Increasing marginal cost of production

In this case, we assume that the marginal cost of producing a quantity $Q$ of GM product for any processor $k$ is $c^k_g(Q) = c^k_g Q$ and the marginal cost of producing non-GM is defined as $c^k_n(Q) = c^k_n Q$, with $\forall k, c^k_n > c^k_g$. Profits for processor $k$ will be defined as $\Pi^k = (p_i - c^k_i(S_i q^k))S_i q^k$, where $q^k$ is the number of customers of processor $k$, and $p_i$ is the price of product $i$. In addition, for the voluntary labelling case, the cost of keeping ingredients segregated from conventional ingredients is $C$.\(^{21}\)

Similarly, the processors will choose the largest profit between GM and non-GM under the two alternative labelling regimes. Their decision is based on expected demands and cost differences, while prices are exogenous in the short run. We determine the decision rules whether to produce GM or non-GM for each type of expected demand.

Our results are presented in figure 5.\(^{22}\) This three-dimensional figure shows parameter values that determine whether GM is more profitable than non-GM. The first horizontal axis (labelled $S_g$) corresponds to the expected market share of the GM product (given prices and the taste parameter $\lambda$).

The second horizontal axis is defined as the price ratio of GM to non-GM for processors (for the case of voluntary labelling, this is not the retail price). The vertical axis measures the cost coefficient ratio of GM to non-GM. The upward sloping surface is the isoprofit surface, where processors will be indifferent between producing GM or non-GM. Above this surface, the processor will adopt non-GM ingredients. Below this surface, processors will choose to produce with GM ingredients.

To facilitate the interpretation of this figure, we present a projection of the surface in figure 6. The horizontal axis corresponds to the expected share of GM. The vertical axis corresponds to the ratio of the cost coefficients. The isoprofit frontiers are lines depending on the producer price ratio. When the prices of

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21 The different profit functions are reported in the electronic appendix (see fn 14).
22 The derivations are shown in the electronic appendix (see fn 14).
FIGURE 5 Processors’ decision to produce GM versus non-GM with increasing marginal costs: isoprofit surface

GM and non-GM are equal, the projected frontier lies in the middle of figure 6, meaning that the cost ratio will not dramatically affect the decision of the processors. When the price ratio is equal to 0.5, the GM area is reduced, because non-GM is more profitable in most cases. Similarly, for cost ratios closer to 1, the processors will be less likely to choose GM than when the cost ratios are less than 1, because the lower the cost of GM compared with non-GM, the more profitable GM products are. Finally the larger the expected GM market share, the more likely processors will choose GM.

This representation is also applicable to understanding the impacts of the introduction of either mandatory or voluntary labelling. Comparative static results are shown in table 4 below figure 6. The expected market share of GM will be larger under voluntary labelling. We can draw a similar conclusion to that reached in the case of constant marginal costs. Since the industry has a lower expected GM share under mandatory labelling, processors will be more likely to choose non-GM ingredients. If the processor price difference increases, then the GM to non-GM price ratio decreases, and the expected market share of GM will increase but the isoprofit frontier will also shift to the right in figure 6. Thus, if a processor starts in the non-GM region and the price of GM falls, the processor will switch to GM only if the expected share increases by more than the associated loss of profits. This will be more likely if the original consumer acceptance for GM is relatively high (low $\lambda$). To sum up:
FIGURE 6 Two-dimensional projection of the processors’ decision to produce GM versus non-GM with increasing marginal costs. The isoprofit frontiers are represented (from right to left) for GM to non-GM price ratios between 0.5 and 1.

TABLE 4
Effects of changing different parameters on the position of a processor in figure 6

<table>
<thead>
<tr>
<th>p_g</th>
<th>p_n</th>
<th>c_g</th>
<th>c_n</th>
<th>C</th>
<th>λ</th>
<th>τ</th>
<th>β_1</th>
<th>β_2</th>
<th>Voluntary</th>
</tr>
</thead>
<tbody>
<tr>
<td>←</td>
<td>→</td>
<td>↑</td>
<td>↓</td>
<td>→</td>
<td>←</td>
<td>→</td>
<td>←</td>
<td>→</td>
<td>←</td>
</tr>
</tbody>
</table>

Frontier movement

Note: The movements in parentheses are uncertain: they depend on the degree of transmission of the certification cost to the retail price.

With increasing marginal costs of production, we find the same qualitative results as with constant marginal costs. Under both labelling policies, processor choice will depend on the cost and price ratios of the two types of ingredient and the expected market share of consumers buying GM products.

2.2.3. Product type

For a given expected market share (a vertical segment in figures 4 and 6), for either cost structure, we can show that the product’s characteristics may also influence the processor decision.

Highly processed products. Some food products will require a very small portion of the decision ingredient: GM or non-GM. In this case, the cost of purchasing non-GM rather than GM ingredients will not be particularly important for the processing firm (e.g., the cost share of raw grain in a box of breakfast cereal is very small).
With a small cost difference, we expect the non-GM to GM profit ratio to be close to the price ratio. In a country with mandatory labelling, the price ratio will just exceed 1.0, which means that if the expected market share of GM is less than one-half (in figures 4 and 6), the processors will choose non-GM. The profit ratio will be the same under a voluntary labelling situation (e.g., in Canada) if we assume that the additional cost $C$ is fully transmitted to the price. The expected share of GM will differ according to the price premium and will shift more towards the right (in figures 4 and 6) for the voluntary labelling case relative to the mandatory labelling case. However, the increasing risk of a bad reputation effect due to a new mixing scandal (such as Starlink corn, Prodigene corn, and Liberty Link rice) will may push these firms to fear a backlash consumption effect, which potentially would reduce dramatically the expected market share of GM. In both cases, firms will be either in the non-GM region or close to the isoprofit curve. This means that they may choose non-GM ingredients even if GM ingredients are cheaper and they do not face mandatory labelling requirements. This can be observed in North America with the choice of some large processors to go with non-GM (such as Frito-Lay), or with the opposition to commercialization of GM wheat by some large food processors (e.g., General Mills).

**Fresh products.** At the ingredient level, fresh produce (e.g., bananas, tomatoes) may have a larger cost difference between GM and non-GM. We can expect a non-GM to GM profit ratio to be less than one for some firms, and thus they will choose to produce GM because of the cost advantage. So there will be a greater chance of the coexistence of GM and non-GM goods produced for food products that require relatively little processing. However, at present there is little or no commercial production of GM fresh produce.

We summarize our conclusion in the following proposition:

Under any labelling policy, for a given price difference, processors (and retailers) will be more likely to market GM fresh products than GM highly processed products, because the GM versus non-GM cost differences with fresh products will increase their profits.

2.3. Aggregation of the choices: market outcome

In this section, we close the model by determining the equilibrium prices and quantities in the long run. Until now, we viewed prices as exogenous, and processors chose ingredients as a function of the expected GM market share and their costs. But after the processors make the ingredient decision, the market for GM and non-GM products adjusts to market equilibrium. We then consider a last step, the long-run sustainability of the equilibrium under each type of labelling.

We adopt the assumption of increasing marginal costs of production, so that $p_i = c_i Q_i$. The processors face the same aggregate demand for GM and

23 In the case where marginal costs are constant under perfect competition, prices are always exogenous.
non-GM food, but we will assume that they face different costs of production. We suppose that for any processor \( k \): \( c_i^k (Q) = c_i^k Q \), where \( i = g, n \), and that the cost coefficients for non-GM are constant across firms (i.e., \( \forall k, c_n^k = c_n \)) and \( c_g^k \) follow a uniform distribution \( U[c_g, \bar{c}_g] \), where \( c_g \) and \( \bar{c}_g \) are the minimum and the maximum GM cost coefficients, respectively. In what follows, we define \( \phi = \lambda (1 - \tau) / (\beta_1 + \beta_2/2) = 2\lambda(1 - \tau)/(1 + \beta_1) \) as a parameter representing the general sensitivity of consumers in a given country.

Each processor decides whether or not to use GM ingredients, and to label their products accordingly, given prices. As a result of their choice, there are three possible outcomes:

- **Corner solution 1**: All processors use GM ingredients, under mandatory labelling they all label, under voluntary labelling no product is labelled;
- **Corner solution 2**: All processors use non-GM ingredients, under mandatory labelling they do not label their products, under voluntary labelling they all label their products;
- **Interior solution**: some processors choose GM ingredients, others choose non-GM ingredients, under both labelling regimes some products are labelled and some are not.

For each case, we focus on the equation defining the isoprofit line in figure 6 and rewrite the definition of each region in that figure. We then derive the critical conditions for the processors’ dichotomous choice between GM or non-GM ingredients.\(^{24}\)

- **Corner solution 1**: GM only.

As we argued in section 2.2, this corner solution with only GM will be more plausible under voluntary labelling in our countries of study.

Under voluntary labelling, any individual processor \( k \) will use only GM ingredients for his product if consumer concerns are relatively limited (low \( \lambda \) implies low \( \phi \)), if there is a relatively large population share of trusting consumers (large \( \beta_1 \) and low \( \phi \)), and if the profitability of GM relative to non-GM is large. This will be the case for products with cheaper GM ingredients and in countries with fewer consumer concerns over GM foods.

Based on our derivation of the market equilibrium, we derive a sufficient condition under which processors continue to produce GM. We find that this stability condition will be violated if the coefficient \( \phi \) is large enough, that is, if there is a sufficient willingness to pay or if there are less trusting consumers. Therefore, the equilibrium will not be stable if the degree of concern about GM foods.

\(^{24}\) Detailed results are shown in the electronic appendix (see fn 14).
What labelling policy for consumer choice?

is within a specific range of values. This will happen especially if the cost of GM is close to the cost of non-GM.25

- Corner solution 2: only non-GM.

In some countries with mandatory labelling, such as the EU or Japan, virtually all processors have chosen to use non-GM ingredients in order to avoid labelling their products. Under this labelling regime, individual processors will choose not to label and to use non-GM ingredients only if there is a strong preference for non-GM (large $\lambda$), if there is a relatively large share of distrusting consumers (large $\beta_2$), or if the relative profitability of offering GM is small. This is most likely the case in countries where consumers oppose GM foods.

We derive a sufficient condition for processors to use non-GM, and compute prices and quantities at the equilibrium. We find that this corner solution with only non-GM products will be sustained in the long run, ceteris paribus.

- Interior solution: both GM and non-GM.

In the case of mandatory labelling, if the condition required for the presence of non-GM is not satisfied for some processors, there will be coexistence of GM and non-GM. This outcome means that consumers are not so concerned about GM, or that a sufficiently large share of them are trusting, or possibly that GM is more profitable for some firms. To compute the equilibrium, we use the supply and demand functions. We find that the price of GM food is positively correlated with the number of products sold and negatively with the degree of sensitivity to GM ($\phi$). The price of non-GM food is positively correlated with the sensitivity parameter $\phi$, as expected.

Similarly, in the case of voluntary labelling, if the sufficient condition for processors using GM is not satisfied, at least for some processors, there will be coexistence of GM and non-GM. This means that some consumers are concerned over GM, or that a sufficient share of consumers is distrusting, or that non-GM is not more profitable for some firms. We use supply and demand equations to derive the equilibrium. Compared with mandatory labelling, we find that voluntary labelling results in higher quantities of GM products ($Q^v_{ml} \geq Q^v_{vl}$ with $ml$ superscript for mandatory labelling and $vl$ for voluntary labelling), as expected. In addition, the producer prices will generally be ranked as follow: $p^m_{g} \leq p^v_{g} \leq p^v_{n} \leq p^m_{n}$; that is, the producer price wedge under mandatory labelling will be larger than under voluntary labelling. For consumers, this means that GM will be cheaper under mandatory than under voluntary labelling.

The interior solution is the most general case and its sustainability is more difficult to assess. There may be an increase in the price of non-GM relative to

25 Idem.
GM, which means that the frontier in figure 6 will shift to the right, potentially encouraging more firms to choose non-GM ingredients. But at the same time, the share of GM customers (or the probability of a single firm selling a GM product) will increase (as shown in table 3). As a result, the mixed equilibrium may be stable and will depend on the difference between changes in relative price and in market shares.

Therefore we come to the following conclusion. First, voluntary labelling is less likely than mandatory labelling to reach a sustainable corner solution with one type of product, but its provision of consumer choice will critically depend on consumer perception. Second, with the interior solution, the quantity of GM products will be superior with voluntary labelling than with mandatory labelling, and the difference between GM and non-GM producer prices will be higher with mandatory labelling than with voluntary labelling. Third, the sustainability of the interior solution will depend on the difference between changes in relative prices of GM and changes in the market share for GM.

- Taste and consumer choice

To better analyse this last result, we need to evaluate the response to changes in consumer tastes with both labelling systems, because market shares critically depend on taste. We find that the market share of GM is more affected by the sensitivity parameter $\varphi$ under voluntary labelling than under mandatory labelling, because of the certification cost under voluntary labelling. The marginal effect of a change of $\varphi$ on the market share under voluntary labelling is greater than the marginal effect under mandatory labelling: $\partial S^v / \partial \varphi = -(p_n + C - p_g) / \varphi^2$ and $\partial S^m / \partial \varphi = -(p_n - p_g) / \varphi^2$ so $|\partial S^v / \partial \varphi| > |\partial S^m / \partial \varphi|$. Under mandatory labelling, the corner solution with only non-GM can be sustained as long as there is no sharp change in consumer perception, and cost differences remain low. Firms may take time to change. In contrast, under voluntary labelling, consumers must have a sufficient demand for non-GM products. To reach the corner with non-GM only, there must be demand for the non-GM products even though they sell at a price premium.

In addition, in countries where the perception of GM food is low (i.e., a high coefficient $\varphi$), the expected market share will change more slowly than in countries where acceptance is higher (with a lower $\varphi$). So in the EU, where mandatory labelling is implemented and there is large opposition to GM foods, for a given shift in perceptions labelled products will take a long time to appear on the market. In Canada, where there is relatively greater consumer acceptance, if the consumer opinion changes against GM, non-GM products will appear more rapidly.

Similarly, a change in the price premium will have a stronger effect on countries with less opposition to GM food, as $\partial S_g / \partial (p_n - p_g) = 1 / \varphi$. Consumers in these countries are more sensitive to prices. Everything else being equal, countries with higher consumer concerns are more likely to remain covered by non-GM products with an increase in the price premium.
We summarize these results with the following proposition:

*Voluntary labelling allows the market to respond more directly to changes in consumer perception than mandatory labelling does. Moreover, in countries with low consumer acceptance of GM food and mandatory labelling, an increase in consumer acceptance or in the non-GM to GM retail price premium may not result in a large number of processors switching to GM products, ceteris paribus. In contrast, in countries with a higher acceptance of GM food and a voluntary system, the market outcome will be more likely to respond to a change in prices or consumer perceptions.*

3. Conclusions

Canada has a voluntary labelling scheme for genetically modified (GM) food, while the European Union (EU) has mandatory labelling. Voluntary labelling may give consumers a choice in a country where some consumers are opposed to GM foods, but if the labelling and segregation costs exceed what consumers are willing to pay for non-GM, it may also lead to a market outcome with only GM products available. On the other hand, when regulation requires processing firms to label GM ingredients, they may stop offering GM products altogether. So ironically, mandatory labelling may remove consumer choice, even though choice is one of the main justifications for this policy. Labelling laws therefore can serve as a market barrier. Even if the government approves the growing of GM crops, food industries might reject these crops because of labelling regulations.

In this paper, we show that mandatory labelling increases the likelihood of processors using only non-GM ingredients in countries where consumers have a negative perception of GM food. We find that voluntary labelling is more likely to provide consumer choice, because under this scheme the market share of GM is more directly linked to consumer acceptance of GM food. Mandatory labelling will be more likely to sustain a corner outcome with only non-GM products (or all GM products in countries with low consumer opposition to GM food). In other words, a bottom-up approach of labelling (voluntary) will do more in terms of honouring consumer choice than the top-down approach of labelling (mandatory), because of the effect of labelling on processors and retailers.

As a consequence, the choice of ingredients by intermediary firms is crucial in terms of determining the market outcome of any labelling policy. This result has direct policy implications. Consumer surveys should not be considered the one and only tool to determine the value of a labelling policy; they should be conducted along with surveys of processors and retailers.

This result also suggests that the assumption of exogenous quality, commonly used in theoretical or empirical studies on the effect of information disclosure policies is not always innocuous. The case of GM food suggests that the more negative the labelling attribute is (from the perspective of consumers), the more likely quality changes will matter. For instance, mandating the disclosure of trans fats will likely result in most concerned food companies’ changing ingredients as
a result of the labelling law. It is also likely that nutrition labelling will result in significant changes in ingredients in processed food products with fat or other negative attributes.

We also show that GM food labelling policies have different effects depending on the type of food product. Fresh products such as produce are more likely to be present in both variants than highly processed products under both labelling schemes. In countries that require labelling and approve only the growing of GM ingredients that must be processed, it is not surprising to find no GM products on the retail shelf. It is also interesting to note that, in voluntary labelling countries, some processing firms do not use GM ingredients, but they do not label their products as non-GM either, probably because they fear reputation loss. More research is needed on the effect of risk aversion on voluntary labelling.

Political economy factors also affect policy decisions in the case of GM foods (Bernauer and Meins 2001). In the EU, Kalaitzandonakes and Bijman (2003) argue that the implicit GM food ban was initiated by large retailers. Processors were following the retailer’s lead. The BSE scare may be one reason why the retailers reacted so strongly and refused to carry GM products. Environmental pressure groups also started to target products with labels. Most environmental groups support mandatory labelling for the sake of consumer choice and consumer information, but ironically it tends to reduce consumer choice. Anti-GM pressure groups have greater difficulty influencing consumers under voluntary labelling, and this is another reason why voluntary labels are more likely to provide choice. In these political games consumers play an insignificant role. GM food’s bad reputation in the EU is largely due to unrelated food scares and other preconceived attitudes towards the private developers of the technology.

If the EU had implemented voluntary labelling, it is likely that its market would now offer more GM products at the retail level. However, it still may have ended up with almost all non-GM products. But this outcome would have been more directly due to consumer choice rather than indirectly determined via processor choice. If Canada had implemented mandatory labelling, the market would most likely be largely supplied with non-GM products, but because of the asymmetric effect of mandatory labelling there would be a higher risk of reaching a complete corner solution. These two regions have chosen a specific labelling policy in part because of consumer perception and their degree of confidence in food agencies. Our results show that the choice of labelling policy does, in fact, reinforce the bias towards non-GM products in the EU and GM products in Canada. EU consumers may see a warning signal with a GM label, and North American consumers may find the voluntary labelling guidelines a way to marginalize non-GM products as a niche market supplied by organic foods.

What will happen if new GM products are developed and the GM image becomes more positive? If these products have nutritional benefits, there is a substantial price difference, or they are environmentally beneficial, it is likely
that consumer choice will play a greater role. The brief introduction of the GM Calgene’s Flavr Savr tomato paste (that was voluntarily labelled) was a marketing success in the United Kingdom before the GM crisis occurred. For the first generation of agricultural biotechnology products, any success of efforts to bring this technology to the market in rich countries is related not only to consumer perception, but also to processor profitability. If the economic rents from GM crops are captured mainly by farmers and the seed industry, then food-processing cost differences will be small and processors may not give consumers a choice in countries with mandatory labelling.

Eventually, the social welfare implications of labelling policies will be related to the presence of consumer choice. As we show in this paper, a loss of consumer choice (i.e., no choice) can result in an economic welfare loss if some consumers are willing to buy the alternative. In this case, the aggregate welfare outcome will depend on the importance (and weight) of the smallest group, its valuation for the alternative product, and the cost of producing both. But obtaining consumer endorsement is not sufficient to warrant a welfare gain, as any type of labelling policy may also be inferior to the outcome under no labelling. If there is a general lack of demand for the labelled information (on a product characteristic), or if the value of such information does not cover its costs, the issue of consumer choice will be irrelevant and in order to maximize social welfare, labelling should be avoided.

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