UNIVERSITÀ DELLA CALABRIA
Dipartimento di ECONOMIA e STATISTICA

UNIVERSITÀ CATTOLICA DEL S. CUORE, PIACENZA
ISTITUTO DI ECONOMIA AGRO-ALIMENTARE

UNIVERSITÀ DEGLI STUDI ROMA TRE
DIPARTIMENTO DI ECONOMIA

UNIVERSITÀ "LA SAPIENZA" DI ROMA
DIPARTIMENTO DI ECONOMIA PUBBLICA

UNIVERSITA' della TUSCIA
Dipartimento di Economia
Agroforestale e dell'Ambiente Rurale

I N E A
Istituto Nazionale di Economia Agraria

MINISTERO DELL'UNIVERSITÀ E DELLA RICERCA SCIENTIFICA E TECNOLOGICA - PROGRAMMA DI RICERCA SCIENTIFICA DI RILEVANTE INTERESSE NAZIONALE

"IL NUOVO NEGOZIATO AGRICOLO NELL'AMBITO DELL'ORGANIZZAZIONE MONDIALE DEL COMMERCIO ED IL PROCESSO DI RIFORMA DELLE POLITICHE AGRICOLE DELL'UNIONE EUROPEA"

A simple model of voluntary vs mandatory labeling of GMOs

Stefanie Kirchhoff
(Centre for Development Research - University of Bonn)

Angelo Zago
(Dipartimento di Scienze Economiche - Università di Verona)

Working Paper 7/01

Settembre 2001

A simple model of voluntary vs mandatory labeling of GMOs*

Stefanie Kirchhoff
Center for Development Research - University of Bonn
Walter-Flex-Str. 3, D-53113 Bonn -Germany
st.kirchhoff@uni-bonn.de

Angelo Zago
Dipartimento di Scienze Economiche - University of Verona
Via dell'Artigliere, 19 - Verona 37129 - Italy
angelo.zago@univr.it

First draft - September 7, 2001

Abstract

We consider the welfare impact of the mandatory and voluntary labeling policies to inform consumers on GMOs content in foods. With a model of vertical differentiation in competitive markets, we evaluate the effects on price equilibrium and welfare levels. The model provides a potential explanation of observed differences in preferences across countries and affected groups. We find that the mandatory labeling scheme would be optimal in those countries with more GMO-averse consumers and GMO-free producers. Voluntary labeling would instead optimally be chosen in those countries where producers are using GMOs and consumers are more concerned about the cost savings resulting in this technology adoption. We derive the socially-optimal scheme and show how it depends on the parameters of the problem, notably consumer preferences and costs of the different schemes.

* We benefitted from the valuable comments of J. List, G. Sheriff and participants at the 2001 AAEA Meeting in Chicago-IL. The usual disclaimer applies. The financial support of the Italian Ministry for University & Research-MIUR (Zago), under the National Program on "The WTO negotiation on agricultural and the reform of the Common Agricultural Policy of the European Union", is gratefully acknowledged.

1 Introduction

In recent years, there has been a substantial amount of public discussion and concern, both at national and international level, about issues of food safety and the environmental impact of consumer goods. One example for all exemplifies the amount of attention drawn among consumers, firms, and policy-makers alike by these concerns: the controversy on genetically manipulated products (GMOs). GMOs are agricultural products in which some forms of gene splicing has occurred. Indeed genetic engineering involves the transfer of genetic information from one organism to the other to ensure traits such as insect or herbicide resistance, to improve potential yields, and to enhance nutritional or other characteristics.

Opponents of GMO products are concerned about the possibility that some pest-resistant traits may be spread to other less valuable plant varieties in the environment (Economist, 2000a). Another concern is that the transfer of some allergens or carcinogens may pose unknown risks to human health (Economist, 1999a). Some are also worried that the use of marker genes to identify plant resistance to ampicillin may lead to antibiotics resistance (Kinsey, 1999). In addition, there are concerns about the consolidation in the control of GMOs by a small number of big patent-owners and the possible implications for consumers and family-farms (Falck-Zepeda *et al.*, 1999).

An important aspect of the issue is that the products of concern are indistinguishable to consumers. More often than not the nutritional content is indeed not significantly different

from traditional products, and the only difference is in the technology adopted. Even when the nutritional content is in fact different, consumers may be unable to discern it. In other words, these products or production characteristics are unobservable to consumers and hence are considered credence goods (Caswell and Mojduszka, 1996).

As a consequence, there has been a lot of discussion on the appropriate forms of regulation for the production and trade of GMOs, and in particular on the best way to allow firms and consumers to make informed choices. In some cases opponents are even proposing a ban on these products, and the controversies span from national to international markets. Indeed, some are concerned that these disputes, away from being of relevance only to agricultural interests, may threaten food security and cause disruptions of the global trading system as a whole (Buckingham and Phillips, 2001; Perdikis, 2000; Runge and Senauer, 2000).

One aspect that has caused particular controversy is whether labeling of potential GMO products should be mandatory or voluntary. In general, mandatory labeling implies that all producers of genetically manipulated products - or other products considered by some consumers as "unsound" or "unsafe" - are requested to declare themselves as such through product labels. Some call this option "positive" labeling, since it is informing consumers that a product does contain GMO ingredients (Runge and Jackson, 2000). On the other hand, under voluntary labeling schemes, firms can voluntarily label their products as not genetically manipulated - or more generally, "sound" or "safe". This is referred as "negative" labeling. In both cases the labeling system requires some degree of random monitoring by the government or a third party labeling agency in order to be credible to consumers.

A simple model of voluntary vs mandatory labeling of GMOs

The choice of mandatory vs. voluntary labeling is subject to considerable debate. In the case of genetically manipulated organisms, the United States has generally been in favor of voluntary labeling and recently the FDA reiterated this position. The European Union, on the other hand, together with other countries, such as Australia, Japan, and New Zealand, has taken the stand for mandatory labeling. In addition, it appears that concerned consumers often favor mandatory systems, while producers prefer voluntary systems.

Related to this controversy, several questions arise. Which system is preferable under what conditions? What is the difference in effects of the two systems on the affected parties, including firms and consumers? How do the benefits or costs from the two labeling systems depend on the type of consumers, e.g., their degree of concern over product safety, and the type of firm, e.g., whether it prefers to use GMOs or not? What is the effect of monitoring costs?

In this paper we present a simple model which contributes to answering these questions. The model incorporates the prevailing information asymmetry between producers and consumers and it shows the differences between a voluntary and a mandatory scheme. We discuss the impact of the alternative systems on consumers and producers of different types, and use them to explain the observed preferences for a particular system by different groups or countries.

We then proceed to endogenize the choice of the two systems by letting it be chosen by a social-welfare maximizing government. The results are used to derive the conditions under which mandatory labeling is socially preferable over voluntary labeling and vice versa. We

show that (and how) the answers to the research questions posed above depend on consumer preferences, firms' cost structure, monitoring and labeling costs. In addition, we derive a simple rule that, taking into account these latter parameters, provides a rough indicator of which labeling scheme maximizes total economic welfare.

While the focus of the discussion here is on GMOs, it should be stressed that our results apply equally to many other settings, including environmental labeling (EPA, 1998), the concern over mad cow disease in Europe (Roosen *et al.*, 2001), the impact of shrimp production on local mangrove ecosystems, and many more. The structure of the paper is the following. In the next section, we review the literature on the regulation of GMOs. Part three presents the basic model. The welfare effects of the two alternative labeling systems and the consequences for probable political economy considerations are discussed in part four. We analyze the choice of the socially optimal system in part five. Part six concludes and points out possibilities for future research.

2 Issues and related literature

The issues on GMOs are sometimes overlapping with those regarding food safety in general, a topic that in the last years has gained prominence in the scientific community and policy arena. Some studies have investigated the impact of the adoption of GMOs on economic welfare. Producers do not appear to be the only beneficiaries from their adoption, even though their expected profits increase because either crops become resistant to pests and hence need less chemicals or other inputs, or because they increase yields. Hence the main

incentive for producers to adopt a GMO technology would be related to the possible increased profits. In addition, cost savings or yield increases for producers may translate into reduced market prices, which would benefit consumers alike (Moschini, 2001).

Assuming a homogeneous set of commodities, these studies consider how the distribution of benefits and costs vary among different agents - consumers, producers and GMO-patent firms - and different countries, according to the rate of technology adoption and protection of intellectual property rights. As it is emerging, GMO crops are cultivated mainly in the US, Canada and Argentina, with the lion's share for soybeans, corn and cotton. In a situation with protected property rights, most of the benefits would go to the innovator, to consumers and to producers, both in developed (Moschini and Lapan, 1997; Moschini, Lapan and Sobolevsky, 2000) and developing countries (Nielsen and Anderson, 2000).

The above set of studies consider a simplified setting, that is a world where there are no risks, informational asymmetries, etc. In reality, consumers in many countries have strongly manifested their opposition to GMO products. Some consumers are worried by health risks, such as allergies to new proteins and antibiotics resistance. Others oppose GMOs on ethical principles, arguing against unnatural genetic manipulation (Gaskell *et al.*, 1999). A strong case is also made by those who fear unknown long-term health impacts (Hobbs and Plunkett, 2000). Based on these concerns, consumers demand the right to know and governments try to deliver on it (Caswell, 1998, 2000a).

Few would argue that markets are efficient in ensuring optimal resource allocation in the case of GMO products, as they are recognized as being an example of credence goods, i.e.,

goods whose quality is difficult to ascertain by consumers both before and after consumption (Nelson, 1970). Thus, some form of intervention in order to correct market failures due to information asymmetry is needed. The relevant question is in fact which is the optimal regulation of GMO products use and trade.[1]

The positions and the proposed solutions are very different. For example, some firms are voluntarily certifying that their products are GMO-free. Some retailers are banning all food items with any GMO-based ingredient and selecting suppliers accordingly (Economist, 1999c and 2000c). Many countries are considering either restricting or banning imports of GMO commodities (IATRC, 2001). The European Union has already enforced a mandatory labeling regime, soon to be followed by other major countries.[2]

The main controversy is now regarding the use of labeling, and in particular whether it should be mandatory or voluntary. One can summarize the literature by noting that in the majority of studies voluntary labeling emerges as better for economic welfare. The need to enforce labeling or minimum safety standards emerges when one considers food safety problems in a situation of asymmetric information and credence goods. For example, Marette *et al.* (2000) using a two-period model of a monopolistic market, show that the optimal regulation is represented by voluntary labeling together with third party monitoring. Crespi and Marette (2000), studying how food safety should be financed in a single period

[1] Segerson, extending her own research on voluntary vs. mandatory approaches to environmental regulation, considers food safety problems and argues that "... in the case of credence goods, adequate consumer protection is likely to be achieved only with some form of government intervention..." (Segerson, 1999: p. 68).

[2] Indeed, the dimension of the problem is now international, with the GMO products being seen as an example of the risks associated with globalization and the controversy about their trade as an opportunity to oppose trade liberalization (Runge and Jackson, 2000).

model, find the advantage of a voluntary labeling system financed with a per-unit fee that maintains competition among safe sellers. Indeed, a voluntary scheme would be sufficient, i.e., better, when there is more than one seller, whilst a mandatory scheme would be needed with a monopolist.

A parallel but less formal strand of literature argues against mandatory labeling. The main argument is to "let the market decide" (Sheldon, 2000), and the case is made both in the country-based case and for international trade in general (see, e.g., Runge and Jackson, 2000). One argument made is that the costs of mandatory labeling would be higher because of the need to segregate[3] , while the benefits would be similar to those of voluntary labeling and would accrue only to part of the consumers. However, governments may choose to incur the additional costs to deliver on what they perceive as consumers' rights to know, at least in those countries where concerned consumers are numerous. For this reason, one should expect in the future to see both countries with mandatory and voluntary labeling (Caswell, 2000b).

In addition, arguing that voluntary labeling is to be preferred, Runge and Jackson (2000) recognize that the information provision through labeling is a form of public good and governments ought to share responsibility for its implementation. They also argue for harmonization efforts by supranational bodies, e.g., the FAO, to ensure a common labeling system to be enforced at the WTO level. In fact, who should regulate these and other matters, e.g., antitrust cases in the international arena, is another very controversial issue (Neven and Roller, 2000).

[3] As a matter of fact, the need to segregate is shared also by voluntary labeling policies.

But while the economic analysis seems relatively unanimous in arguing for the superiority of the voluntary approach to labeling, the fact is that in the policy arena the issue is controversial and only few countries, for instance those with a high percentage of GMOs in total production, are in fact implementing voluntary labeling (IATRC, 2001). Consumers' concerns, which are asymmetrically distributed across countries (Gaskell *et al.*, 1999), matter as well. In an empirical study, for example, Roosen *et al.* (2001) find that 90% of consumers in France, Germany and the UK desire a mandatory labeling program for beef produced from cattle fed with genetically modified crops.

To explain the observed variation in actual positions regarding the choice of labeling system, one has to consider differences in consumers' and producers' interests in different countries. In this regard, Giannakas and Fulton (2001), in a paper most related to the one we propose, take explicit account of the heterogeneity in consumers' preferences and the different costs they may face with diverse policy options. In this fashion, they rationalize the requests for a ban on GMO-based commodities when these are perceived as different from GMO-free products. In addition, they rank the no-labeling to the mandatory labeling policy according to the degree of aversion to GMO-food, the segregation costs, the share of GMO markets and the extent of mislabeling.

However, the above study does not consider the choice of mandatory vs. voluntary labeling. Moreover, it focuses on consumers' welfare only and does not consider producers' preferences. In this paper we tackle the question of mandatory vs. voluntary labeling, taking explicitly into consideration differences in consumers' preferences and producer types, costs

of different policy options, and the distribution of benefits and costs to different interests in a single country or in an international setting. Our objective is to present a model that can explain the different positions in the policy arena and be the basis for some welfare comparisons and policy evaluations.

3 The model

3.1 The basic setup

Suppose that a given agricultural commodity, e.g., soybeans, can be produced either with Genetically Modified Organisms (GMOs) or with a more traditional technology, i.e., GMO-free seeds and agronomic practices. There are two types of firms, with each type corresponding to these two options and having different production costs. The GMO-based firms have unit costs of production equal to c_u, whilst the GMO-free firms have unit costs of production of c_s.[4] We assume that the use of GMOs allows producers to reduce their production costs, i.e., $c_s > c_u$.[5]

We also assume that within each group of firms there is perfect competition, so that the market price will be determined only by marginal costs. With these latter - as we will see below - we include production costs as well as labeling costs and segregating costs. Although under this assumption profits are zero, we assume that firms prefer higher to lower market shares.

[4] Here s stands for "sound" or "safe" to indicate also that this model is more general and applies to a whole range of issues other than GMOs, such as environmental labelling, textiles produced without the use of child labour, etc.

[5] For example, "...Roundup Ready (RR) soybeans [..] developed in the United States by Monsanto, are tolerant to a particular herbicide and allow farmers to cut costs by saving on less effective herbicides..." (Moschini *et al.*, 2000: 34).

A simple model of voluntary vs mandatory labeling of GMOs

There is a continuum of consumers, each of which buys one unit of the good. They all value the basic utility from the good as a, where $a \geq c_u$.[6] However, consumers also value - to varying degrees - the fact that a product is GMO-free. Let this valuation be given by $\rho\theta$, where $\rho \in [0, 1]$, and θ is a parameter representing the maximum valuation of GMO-freeness, with $a + \theta > c_s$.[7] Thus, consumers who are less concerned about the potential negative impacts of GMOs would have a low value of ρ, while a high value of ρ indicates that a consumer is very concerned.

Let P_s^i denote the price of GMO-free products, where $i \in \{m, v\}$ and "m" denotes a mandatory labeling system, whilst "v" stands for a voluntary labeling regime. Similarly, P_u^i denotes the price of GMO-based products. Consumers' utility, in monetary terms, from buying a GMO-based product is thus $U_u^i = a - P_u^i$, and that from buying a GMO-free product is $U_s^i = a + \rho\theta - P_s^i$.

Thus, for given prices, consumers buy GMO-free products if $U_s^i = a + \rho\theta - P_s^i \geq a - P_u^i = U_u^i$, and they buy GMO-based products otherwise.[8] Hence, we have that consumers with $\rho \geq \frac{P_s^i - P_u^i}{\theta}$ buy the GMO-free good and those with $\rho < \frac{P_s^i - P_u^i}{\theta}$ buy the GMO-based good. Note however that in the absence of a credible labeling system, the two types of products are indistinguishable to consumers.

[6] If $a < c_u$, consumers would never buy the GMO-based good. We focus on the more interesting case, where net benefits from consumption of the GMO-based good are positive.
[7] If $a + \theta < c_s$, even the most concerned consumer would never buy the GMO-free good, a case which is of little interest for our purposes.
[8] For simplicity of exposition, it is assumed that in case of indifference, i.e., $U_s^i = U_u^i$, consumers buy the GMO-free product.

3.2 Voluntary labeling

With voluntary labeling, GMO-free firms can distinguish themselves from GMO-based firms through labeling. However, the labeling has to be credible to consumers. Therefore, the GMO-free firms have to build up or support a third-party labeling agency which monitors those firms which use the "GMO-free" label. In this simple model, it is assumed that the system is structured in such a way that monitoring and fines ensure perfect compliance. The details of such a system are further discussed in Appendix A.

We assume that the costs associated with monitoring costs and enforcement by a third-party labeling agency are borne by the firms which use the label.[9] We use what in the literature has emerged as the optimal financing method (see, e.g., Crespi and Marette, 2000), namely the unit fee. Hence we assume that the labeling costs are equal to C per unit of labeled product. The prices in the resulting market equilibrium are then the following:

$$P_u^v = c_u \tag{1}$$

$$P_s^v = c_s + C. \tag{2}$$

Using our earlier results we find that, with voluntary labeling, consumers with $\rho \geq \widehat{\rho}$, where:

$$\widehat{\rho} = \frac{P_s^v - P_u^v}{\theta} = \frac{c_s - c_u + C}{\theta}, \tag{3}$$

buy the GMO-free product. Their utility is:

$$U_s^v = a + \rho\theta - c_s - C. \tag{4}$$

[9] The nature and extend of the costs are still suject to considerable debate (see, e.g., Nelson, 1999; USDA, 2000). But "...one thing seems apparent; implementing a labeling policy on genetically modified foods is costly, even if the exact magnitude of the costs is unknown..." Huffmann *et al.*, 2001: p. 6).

On the other hand, consumers with $\rho < \widehat{\rho}$ buy the unlabeled or GMO-based product receiving an utility of:

$$U_u^v = a - c_u. \tag{5}$$

3.3 Mandatory labeling

In the case of mandatory labeling, the government requires all GMO-based products to be labeled as such. To make the policy credible, the government has to set up a system composed of monitoring and fines to assure compliance. Assume initially that the total cost of this system is the same as under the voluntary system,[10] but that now this cost is paid by the government,[11] which raises the funds by levying a tax on all consumers for an amount t.[12] Given that the monitoring costs are now distributed among all consumers, we have that $t < C$.[13]

The prices resulting in the market equilibrium with mandatory labeling are now the following:

$$P_u^m = c_u, \tag{6}$$

$$P_s^m = c_s. \tag{7}$$

[10]This assumption is relaxed in Appendix A.

[11]To the best of our knowledge, there is no available data on the financing of labeling programs for GMOs. However, in a recent study of environemtal labeling, EPA found that 9 out of the 18 US programs reviewed are fully financed by government. For programs reviewed outside of the US, the same study reports that in total 12 out of 25 programs are financed by governments, either fully (3 cases) or partially (9) (US-EPA, 1998: p. 22). For other programs, user-fee financing is rising but still a small portion of total outlays of government agencies. For example, USDA's Food Safety and Inspection Service in 1996 raised about only 13.5% of total FSIS outlays through user fees for overtime meat inspections (MacDonald *et al.*, 1999).

[12]Or, equivalently, the costs are paid from existing tax revenues which are then not available for financing of other public goods.

[13]The nature of the mandatory system and the generalizability of this result are further discussed in Appendix A.

In this case, consumers with $\rho \geq \widetilde{\rho}$, where:

$$\widetilde{\rho} = \frac{P_s^m - P_u^m}{\theta} = \frac{c_s - c_u}{\theta}, \tag{8}$$

buy the GMO-free (unlabeled) product and their utility is:

$$U_s^m = a + \rho\theta - c_s - t. \tag{9}$$

On the other hand, with mandatory labeling, consumers with $\rho < \widetilde{\rho}$ buy the products labeled as "GMO-based", with an utility of:

$$U_u^m = a - c_u - t. \tag{10}$$

4 Welfare effects of alternative labeling systems and political economy outcomes

As introduced above, the purpose of the paper is not to give an exact measure of the welfare effects of the different labeling systems but rather to formally show how and why we believe these systems have a different impact on different groups of firms and consumers, so to explain the different positions on which system to enforce in the policy arena. We now examine the welfare effects of the two systems on the different agents involved. The results are used to discuss the likely political economy outcomes.

4.1 GMO-free firms

The market share of GMO-free firms is given by $1 - F(\widehat{\rho})$ and $1 - F(\widetilde{\rho})$ under the voluntary and the mandatory system respectively, where $F(\rho)$ is the cumulative distribution of ρ over

the interval $[0, 1]$. In other words, $F(\widehat{\rho})$ represents the proportion of consumers with a value of $\rho < \widehat{\rho}$, while $F(\widetilde{\rho})$ represents the proportion of those with $\rho < \widetilde{\rho}$.[14]

From eq. 3 and 8 we have:

$$\widetilde{\rho} < \widehat{\rho}, \tag{11}$$

and thus:

$$1 - F(\widetilde{\rho}) > 1 - F(\widehat{\rho}). \tag{12}$$

Thus, under a mandatory system, the sound or GMO-free firms attain a higher market share than under a voluntary system. Therefore they prefer the mandatory system. Intuitively, this happens because a mandatory system does not make them pay all the costs of distinguishing themselves from the GMO-based firms which they incur when having to set up a third-party labeling system under a voluntary system. Note that this type of firms is more common in Europe than in the US.

4.2 GMO-based firms

With the same reasoning, it can be easily shown that GMO-based firms have higher market shares under a voluntary system (given by $F(\widehat{\rho})$) than under a mandatory regime ($F(\widetilde{\rho})$). This is because such a voluntary system imposes all monitoring costs on GMO-free firms, making their products more costly (beyond the price difference caused already by the higher production costs).

These higher costs induce some of those consumers who, under a mandatory system would prefer GMO-free products, to buy GMO-based products under the voluntary system. Note

[14]For example, $F(\widehat{\rho}) = 0.1$ implies that 10% of consumers have a valuation of $\rho < \widehat{\rho}$.

also that GMO-based firms are more common in the US and Canada, for example (Moschini, Lapan and Sobolevsky, 2000).

4.3 "Green" consumers

We may recognize that there are some consumers that would buy GMO-free products under both systems, those who in our model would have $\rho \geq \widehat{\rho}$. These consumers, denoted hereafter as "Green" consumers, prefer the mandatory system because the utility under such a system, $U_s^m = a + \rho\theta - c_s - t$, is strictly greater than that under the voluntary system, $U_s^v = a + \rho\theta - c_s - C$, since $C > t$. The intuition is that a voluntary system passes all monitoring costs onto consumers of GMO-free products, while a mandatory system spreads the costs equally across all consumers, and potentially to other taxpayers which do not even consume the product at all.

The position of these "Green" consumers can be summarized with the following argument: "GMO-based firms are already saving on production costs and they should not receive an additional advantage by making it harder for the good guys to distinguish themselves". These consumers are more easily found in Europe, where a more pessimistic view of technological progress is quite common in intellectual circles and media (Gaskell *et al.*, 1999).[15]

[15]In 1998, a Eurobarometer survey across Europe found that 86% of consumers interviewed believe that food containing GMOs should always be labelled as such (Economist, 1999b). A recent study found that 64%, 60% and 47% of surveyed consumers are less likely to purchase products that contain GMOs in France, Germany and the UK respectively (Economist, 2000b).

4.4 GMO consumers

One has also to recognize that a proportion of consumers do not value "GMO-freeness" *per se* enough to induce them to buy GMO-free products under either system, and these are the consumers with a preference parameter $\rho < \widetilde{\rho}$. We will denote this group of consumers as "GMO-consumers". They would prefer the voluntary system, since $U_u^v = a - c_u > a - c_u - t = U_u^m$.

GMO-consumers pay the same price for the good under both systems, but under the voluntary system they do not have to bear the costs of the monitoring efforts. Their position can be represented by the statement "If the Green consumers think that GMO-freeness is so important to them, then they should pay for the cost of distinguishing these products. We do not care about whether the products are one way or the other, so we should not pay for the distinction." These types of consumers are more common in the United States: indeed, "...Americans generally have a more relaxed attitude towards food than, say, French, for whom it is a cultural matter..." (Economist, 1999b).

4.5 "Borderline" consumers

For those consumers with a preference parameter such that $\widetilde{\rho} \leq \rho < \widehat{\rho}$, purchasing decisions are very sensitive to prices. Indeed, they do not buy products labeled as GMO-based under a mandatory system, but given the higher price of GMO-free products under a voluntary system, they would opt for GMO-based products under this latter regime. We will denote this group as "Borderline" consumers.

These consumers prefer the mandatory system if and only if their utility under that

system is higher than that under the voluntary system. That is to say, only if $U_u^v = a - c_u < a + \rho\theta - c_s - t = U_s^m$, which is equivalent to $\rho \geq \rho^*$, where:

$$\rho^* \equiv \frac{t + (c_s - c_u)}{\theta}. \tag{13}$$

We know that they satisfy $\widetilde{\rho} \leq \rho < \widehat{\rho}$ and this implies that:

$$\frac{c_s - c_u}{\theta} \leq \rho < \frac{c_s - c_u + C}{\theta}.$$

Since $t < C$, the critical value ρ^* will lie within this interval. Thus, we can distinguish two groups of "Borderline" consumers. Those with $\widetilde{\rho} \leq \rho < \rho^*$ prefer the voluntary system, while those with $\rho^* \leq \rho < \widehat{\rho}$ prefer the mandatory system.

4.6 Political economy implications

The results from the previous sections are summarized in figure 1. If policy outcomes are the result of political economy considerations, they are determined by the preferences of those groups which are relatively important in terms of their numbers (and associated votes) or their lobbying ability.

Therefore, our results suggest that we should expect to see a mandatory labeling regime where consumers are relatively concerned about GMOs, where Green consumers are relatively well organized and/or GMO-free firms are prevalent. These conditions can be thought to describe the situation in Europe, Japan, Australia, and New Zealand, which might explain why a mandatory regime has been established there. On the other hand, when consumer concerns about GMOs are less prevalent and GMO-based firms are common and/or politi-

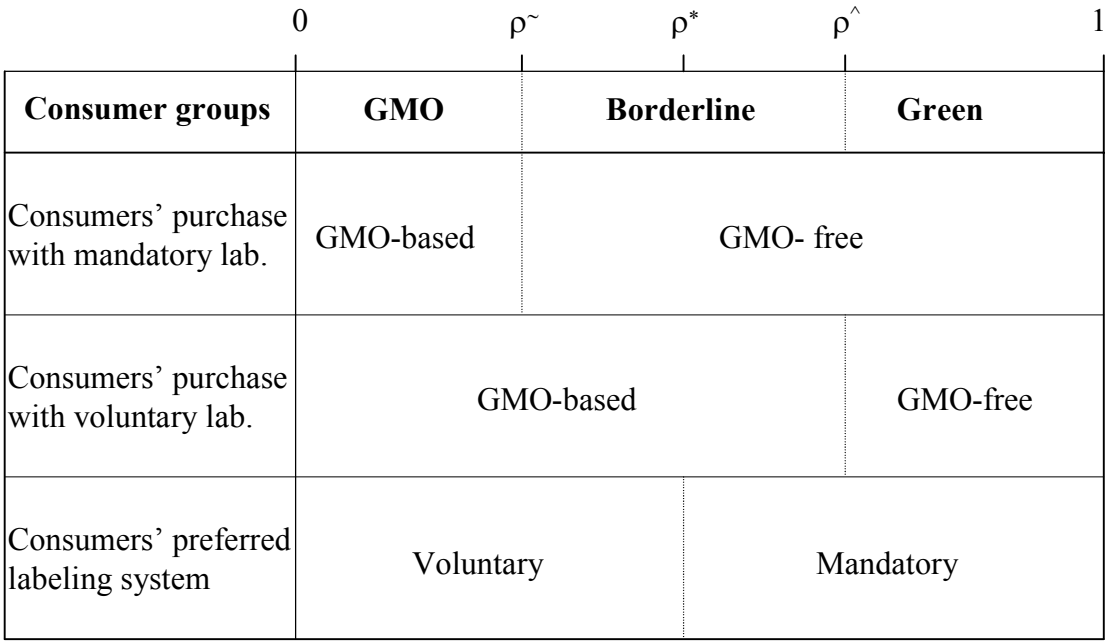

Figure 1: **Consumers' preferences, choices, and preferred system**.

cally powerful, policy-makers are more likely to favor a voluntary over a mandatory system. This might explain the position of countries like the United States and Canada.[16]

5 The socially optimal labeling system

In addition to the political economy considerations discussed above, we are also interested in the conditions under which a mandatory labeling regime is preferred to a voluntary system from the point of view of a welfare-maximizing social planner, and vice versa. Since firms' profits are zero in our model, the socially optimal system is determined by consumers' welfare alone. Assuming equal weights of all consumers[17] and a uniform distribution of consumers'

[16]For the different positions on these issues in the agricultural negotiations under the WTO see, e.g., IATRC (2001).

[17]In fact, some governments may have also some redistributive concerns, but we do not consider those issues here.

preferences, the social welfare under a mandatory labeling system (W^m) can be represented as the following:

$$\begin{aligned} W^m &= N\left[\int_0^{\widetilde{\rho}}(a-c_u-t)d\rho+\int_{\widetilde{\rho}}^1(a+\rho\theta-c_s-t)d\rho\right] \\ &= N\left[a-t-c_s+\widetilde{\rho}(c_s-c_u)+\frac{\theta}{2}(1-\widetilde{\rho}^2)\right], \end{aligned}$$

where N denotes the total number of consumers. Similarly, the social welfare under a voluntary labeling system can be written as the following:

$$\begin{aligned} W^v &= N\left[\int_0^{\widehat{\rho}}(a-c_u)d\rho+\int_{\widehat{\rho}}^1(a+\rho\theta-c_s-C)d\rho\right] \\ &= N\left[a-c_s+\widehat{\rho}(c_s-c_u)-(1-\widehat{\rho})C+\frac{\theta}{2}(1-\widehat{\rho}^2)\right]. \end{aligned}$$

Thus, a mandatory labeling system would be socially preferable to a voluntary system if $W^m > W^v$, i.e., when the following holds:

$$\widetilde{\rho}(c_s-c_u)-t+\frac{\theta}{2}(1-\widetilde{\rho}^2) > \widehat{\rho}(c_s-c_u)-(1-\widehat{\rho})C+\frac{\theta}{2}(1-\widehat{\rho}^2),$$

which is equivalent to:

$$(1-\widehat{\rho})C-t+\frac{\theta}{2}(\widehat{\rho}^2-\widetilde{\rho}^2) > (\widehat{\rho}-\widetilde{\rho})(c_s-c_u).$$

Recalling that $\widehat{\rho}=\frac{c_s-c_u+C}{\theta}$ and $\widetilde{\rho}=\frac{c_s-c_u}{\theta}$ and rewriting $(\widehat{\rho}^2-\widetilde{\rho}^2)=(\widehat{\rho}-\widetilde{\rho})(\widehat{\rho}+\widetilde{\rho})$, the condition for $W^m > W^v$ can be rewritten as:

$$\frac{\theta-c_s+c_u-C}{\theta}C-t+\frac{2(c_s-c_u)+C}{\theta}\frac{C}{2} > \frac{C\,(c_s-c_u)}{\theta}.$$

By way of different steps of simplification, we obtain the following:

$$\frac{\theta-c_s+c_u-C}{\theta}-\frac{t}{C}+\frac{(c_s-c_u)}{\theta}+\frac{C}{2\theta} > \frac{(c_s-c_u)}{\theta}$$

and hence:

$$1 - \frac{(c_s - c_u + C)}{\theta} + \frac{C}{2\theta} > \frac{t}{C}. \tag{14}$$

We can rewrite eq. 14 in the following two ways, which simplify the interpretation:

$$1 - \widehat{\rho} + \frac{\widehat{\rho} - \widetilde{\rho}}{2} > \frac{t}{C}, \tag{15}$$

or:

$$1 - \frac{2(c_s - c_u) + C}{2\theta} > \frac{t}{C}. \tag{16}$$

From eq. 15, we see that a mandatory system is socially preferable to a voluntary regime when the proportion of "Green" consumers $(1 - \widehat{\rho})$ plus half the proportion of borderline consumers $(\frac{\widehat{\rho} - \widetilde{\rho}}{2})$ exceed the percentage reduction in labeling costs borne by those consumers $(\frac{t}{C})$. To illustrate, consider the following example.

Suppose the increase in prices due to labeling costs under a voluntary regime (C) is equal to 5 \$ per metric ton, while the per person cost due to labeling under a mandatory regime (t) is only 2.5 \$. Thus, per person labeling costs for consumers buying the GMO-free product under both systems are, under a mandatory system, only 50% of the corresponding value under a voluntary system, i.e., $\frac{t}{C} = 0.5$. Then, mandatory labeling is socially preferable if the percentage of "Green" consumers, i.e., those buying GMO-free regardless of the system, plus half the percentage of "Borderline" consumers, i.e., those switching from GMO-based to GMO-free goods only when a mandatory system is established, is greater than 50%.

While this provides a decision rule that can be calculated fairly easily from empirical data, it is important to keep in mind that the specific rule requires the assumption that consumers' valuation of GMO-freeness is fairly evenly distributed.

Eq. 16 expresses the condition in terms of the parameters of the model. It shows that mandatory labeling is more likely to be socially optimal if the cost savings from GMOs, $c_s - c_u$, is small, the maximum valuation of GMO-freeness by consumers, θ, is large, the price increase in GMO-free products due to labeling and monitoring costs under a voluntary regime, C, is large, and the per person cost from a mandatory regime, t, is small.

Again, we need to highlight the fact that this condition relies on the assumption of uniformly distributed consumer preferences. A generalization to other preference distributions is left as an extension for future work. However, we would expect these qualitative results to carry through there as well, but that some measure of the skewness of the distribution of preferences towards more or less concerned consumers would enter into the above conditions as well.

6 Concluding remarks

The controversy over which labeling system, either voluntary or mandatory, is to be preferred is igniting debates in the policy arena. Indeed, while economic analysis seems to prefer the former, in reality many countries, e.g., Europe, Australia, New Zealand, and Japan actually have chosen a mandatory system. In this paper we explicitly model the choice between the two systems, taking into account differences in consumers' preference, firm types and implementation costs.

Using a political economy argument, we find that the prevalence of one system over the other depends on the relative importance of different groups of producers and consumers. We

indeed find that mandatory labeling is likely to result in those countries where highly GMO-averse consumers are prevalent and producers are using mainly a no-GMOs technology. On the other hand, when consumers are not strongly averse and prefer the price reduction associated with GMOs and producers mainly adopted GMOs technologies, a voluntary labeling system is more likely to emerge.

From the simple model presented in this paper, we have derived a decision rule for determining whether mandatory labeling is socially preferable to a voluntary labeling regime. While this rule depends on the assumption of uniformly distributed consumer preferences, it can provide a rough approximation for those circumstances in which this assumption appears plausible, and it can be fairly easily computed from empirical estimates regarding consumer groups and monitoring costs. We have also shown that, given the assumptions of the model, mandatory labeling is more likely to be socially optimal when the cost saving from GMOs is small, the maximum valuation of GMO-freeness by consumers is large, and the per person cost implied by monitoring and labeling is relatively large under a voluntary system and relatively small under a mandatory regime.

The intuition behind our results is that mandatory labeling - through the corresponding distribution of monitoring costs across all consumers and firms - lowers the prices for GMO-free goods as compared to a voluntary system where all costs are borne by consumers of these goods. As a consequence, GMO-free consumers face lower prices under a mandatory regime, while GMO-based consumers face relatively higher prices than under a voluntary system. Thus, a mandatory system induces some consumers to switch to a consumption of GMO-free

goods, consumers that under a voluntary regime would buy GMO-based products. This is socially desirable under the above mentioned conditions.

While an extension of the model to less restrictive assumptions on the distribution of consumer preferences is an important issue for future research, we would expect these basic qualitative results to carry through, but with the skewness of the distribution of preferences to enter into the conditions as well.

The model presented in this paper is very simple, yet it captures some of the main aspects of the problem and explains the variation in attitudes observed in reality. One could extend the analysis to consider differences in total monitoring costs in more detail under the two systems, which would likely reinforce the results presented here (see the Appendix). Also, the impact of differences in consumers' confidence across labeling systems provides an interesting subject for future research. In addition, to be more realistic, one should consider the endogeneity of the type of firms. In our model, we assume that producers' type is given. While this assumption appears reasonable in the short run, producers can in the long run decide whether to adopt GMOs technology or not. In addition, one needs to recognize that the two labeling systems may have a different impact on these decisions (Economist, 2000c). One could also consider imperfect monitoring and see whether it can affect the market equilibrium. Another matter for future research include the idea that there may be a need for harmonization of a world trading system in which different systems coexist. These are important issues that deserve more research and modelling efforts.

References

Buckingham, D.E., Phillips, P.W.B., 2001. "Issues and Options for the Multilateral Regulation of GM Foods", *The Estey Centre Journal of International Law and Trade Policy*, Vol. 2 (1): 178-189, available at www.esteyjournal.com (May 2001).

Caswell, J.A., 1998. "Should Use of Genetically Modified Organisms Be Labeled? AgBioForum 1 (1), available at http://www.agbioforum.org/ (May 2001).

Caswell, J.A., 2000a. "An Evaluation of Risk Analysis as Applied to Agricultural Biotechnology (with a Case Study of GMO Labeling), *Agribusiness*, Vol. 16 (1): 115-123.

Caswell, J. A. 2000b. "Labeling Policy for GMOs: To Each His Own?" AgBioForum 3 (1/Winter), available at http://www.agbioforum.org/, (May 2001).

Caswell, J. A. and Padberg, D.I., 1992. "Toward a More Comprehensive Theory of Food Labels", *American Journal of Agricultural Economics* 74(2): 460-468.

Caswell, J. A. and Mojduszka, E. M. 1996. "Using Informational Labeling to Influence the Market for Quality in Food Products". *American Journal of Agricultural Economics* 78: 1248-1253.

Crespi, J. and Marette, S. 2000. "How Should Food Safety be Financed?", presented at the 3rd IDEI-INRA Conference on "Industrial Organization and the Food Industries", Toulouse, June 2000, available at www.idei.asso.fr (May 2001).

Darby, M. and Karni, E. 1973. "Free Competition and the Optimal Amount of Fraud." *Journal of Law and Economics* 16: 67-88.

Economist, The, 1999a. "Seeds of Discontent", February 18th.

Economist, The, 1999b. "Sticky Labels", April 29th.

Economist, The, 1999c. "Genetically Modified Government", May 27th.

Economist, The, 2000a. "A Conventional Argument", January 27th.

Economist, The and Angus Reid Group, 2000b. "International Awareness and Perceptions of Genetically Modified Foods", in Roosen *et al., 2001.*

Economist, The, 2000c. "To Plant or not to Plant", January 13th.

Falck-Zepeda, J.B., Traxler, G., and Nelson, R.G., 2000. "Rent Creation and Distribution from Biotechnology Innovations: The Case of Bt Cotton and Herbicide-Tolerant Soybeans in 1997", *Agribusiness* v16 (1): 21-32.

Gaskell, G., Bauer, M.W., Durant, J. and Allum, N.C., 1999. "Worlds apart? The Reception of Genetically Modified Foods in Europe and the U.S.", *Science* 285 (15 July): 384-387.

Giannakas, K. and Fulton, M. 2001. "Consumption Effects of Genetic Modification: what if Consumers are Right?", forthcoming in *Agricultural Economics.*

Hobbs, J.E., Plunkett, M.D., 2000. "GMOs: The Economics of Consumer Food Safety Issues", *Current Agriculture, Food & Resource Issues*, 1: 11-20, available at www.CAFRI.org (May 2001).

Huffman, W.E. , Shogren, J.F., Rousu, M., Tegene, A., 2001. "The Value to Consumers of GM Food Labels in a Market with Asymmetric Information: Evidence from Experimental Auctions", Paper prepared for the annual meeting of the American Agricultural Economics Association, Chicago, August 5-8, available at http://agecon.lib.umn.edu/ (June 2001).

International Agricultural Trade Research Consortium, 2001. "The Role of Quality Attributes in the Agricultural Negotiations", Commissioned paper no. 17, May.

Kinsey, J., 1999. "Genetically Modified Food & Fiber - A Speedy Penetration of a False Start?", *Cereal Foods World* 44(7): 487-489.

Kirchhoff, S. 1998. "Overcompliance, Labeling, and Lobbying: The Case of Credence Goods." Working paper XX-98, Department of Agricultural and Resource Economics, University of Maryland.

Klein, B. and Leffler, K. 1981. "The Role of Market Forces in Assuring Contractual Performance." *Journal of Political Economy.* 81: 615-641.

MacDonald, J., Kuchler, J., Buzby, J., Lee, F., and Aldrich, L., 1999. "User-Fee Financing of USDA's Meat and Poultry Inspection", Agricultural Economic Report n. 775, ERS-USDA.

Marette, S., Bureau, J.-C. and Golan, E., 2000. "Product Safety Provision and Consumers' Information", presented at the 3rd IDEI-INRA Conference on "Industrial Organization and the Food Industries", Toulouse, June 2000, available at www.idei.asso.fr (May 2001).

Moschini, G.C., 2001. "Biotech—Who Wins? Economic Benefits and Costs of Biotechnology Innovations in Agriculture", *The Estey Centre Journal of International Law and Trade Policy*, Vol. 2 (1): 93-117, available at www.esteyjournal.com (May 2001).

Moschini, G.C., and Lapan, H., 1997. "Intellectual Property Rights and the Welfare Effects of Agricultural R&D", *American Journal of Agricultural Economics* 79(4): 1229-

1242.

Moschini, G.C., Lapan, H., Sobolevsky, A. 2000. "Roundup Ready® Soybeans and Welfare Effects in the Soybean Complex", *Agribusiness*, Vol. 16 (1): 33-55.

Nelson, G. C. (Coordinator), 1999. "The Economics and Politics of Genetically Modified Organisms in Agriculture: Implications for WTO 2000", University of Illinois-College of Agricultural, Consumer and Environmental Sciences, Bulletin 809-November.

Nelson, P. 1970. "Information and Consumer Behavior." *Journal of Political Economy.* 81: 729-754.

Neven, D.J. and Roller, L.-H. 2000. "The Allocation of Jurisdiction in International Antitrust", *European Economic Review*, 44: 845-855.

Nielsen, C. and Anderson, K., 2000. "GMOs, Trade Policy, and Welfare in Rich and Poor Countries", CIES working paper no. 21, May, available at www.adelaide.edu.au/cies (May 2001).

Perdikis, N., 2000. "A Conflict of Legitimate Concerns or Pandering to Vested Interests? Conflicting Attitudes Towards the Regulation of Trade in Genetically Modified Goods – The EU and the US", *The Estey Centre Journal of International Law and Trade Policy*, Vol. 1 (1): 51-6 5, available at www.esteyjournal.com (May 2001).

Runge, C.F. and Jackson, L.A., 2000."Labelling, Trade and Genetically Modified Organisms: A Proposed Solution", *Journal of World Trade* 34 (1): 111-122.

Runge, C.F. and Senauer, B., 2000. "A Removable Feast", *Foreign Affairs* 79(3): 39-51.

Roosen, J., Lusk, J. L. and Fox, J.A., 2001. "Consumer Demand For and Attitudes

Toward Alternative Beef Labeling Strategies in France, Germany, and the UK", Paper prepared for the annual meeting of the American Agricultural Economics Association, Chicago, August 5-8, available at http://agecon.lib.umn.edu/ (June 2001).

Segerson, K., 1999. "Mandatory versus Voluntary Approaches to Food Safety", *Agribusiness* 15(1): 53-70.

Sheldon,I.M., 2000. "No Mandatory Labeling: Let the Market Decide Debate on Biotech Food", The Cleveland Plain Dealer, May 31.

U.S. Department of Agriculture - Economic Research Service, 2000. "Economics of Food Labeling.", Agricultural Economic Report No. 793. (December).

U.S. Environmental Protection Agency, 1998. "Environmental Labeling Issues, Policies, and Practices Worldwide", EPA 742-R-98-009, December, available at http://www.epa.gov/ opptintr/ environmental-labeling/ toc.html, (May 2001).

Appendix A

So far we have assumed that the total costs of ensuring compliance is the same under the voluntary labeling regime as under the mandatory one. Let us now examine this assumption in more detail.

First, it should be noted that the potentially higher willingness to pay of consumers for GMO-free products yields an incentive for GMO-based firms to cheat under both systems. Cheating takes the form of GMO-based firms pretending to be GMO-free. Under a voluntary system this implies that GMO-based firms could label their products as GMO-free. With mandatory labeling, cheating would take the form of GMO-based firms not labeling themselves as such. In both cases, without any monitoring and enforcement, cheating GMO-based firms would receive a price net of labeling costs of c_s which exceeds the price c_u which they could obtain by telling the truth.

Thus, both labeling systems face the problem that monitoring and enforcement are necessary to distinguish GMO-free from GMO-based firms.[18] This usually takes the form of a mixture of monitoring and charging a fine if cheating is detected. In our case, both labeling systems require a monitoring intensity γ^i and a fine F^i so that the expected profit of a GMO-based firm is at least as large when telling the truth than when pretending to be GMO-free, namely:

$$\gamma^i \ (c_u - F^i) + (1 - \gamma^i) \ c_s - c_u \leq c_s - c_u,$$

[18]This is the common result that no signalling equilibrium exists with credence goods (see, e.g., Caswell and Padberg, 1992; Kirchhoff, 1998).

or equivalently:

$$\gamma^i \geq \frac{c_s - c_u}{c_s - c_u + F^i}. \tag{A1}$$

It is a well known result that cheating can be deterred without monitoring if the fine can be chosen to be very large. However, in reality the maximum fine that can be enforced usually does not satisfy this condition. Let us consider $\overline{F}^i$ to be the exogenously given maximum fine. Since monitoring is costly, the monitoring intensity under both systems should be minimized subject to the constraint that it deters compliance (eq.17). Thus, we obtain:

$$\gamma^{i*} = \frac{c_s - c_u}{c_s - c_u + \overline{F}^i}.$$

Thus, if the maximum enforceable fine is the same under both labeling systems ($\overline{F}^m = \overline{F}^v$), then the cost-minimizing monitoring intensity that ensures full compliance is the same under both systems as well. In that case, our assumption that total monitoring costs are the same with mandatory as well as voluntary labeling would seem plausible.[19]

What if maximum enforceable fines differ across systems, however? We would argue that the more realistic case then is the case where $F^m \geq F^v$. Under a mandatory system the punishment for cheating can be established in the form of laws. By contrast, in the case of voluntary labeling, the labeling agency may find it more difficult to enforce large punishments. Moreover, it should be noted that F^i can be interpreted as including the punishment executed by consumers directly in the form of boycotting firms found cheating

[19]This does not necessarily hold, however, when there are differences in fixed costs across the two systems. This case is ignored here and left for an extension. Note, however, that our results remain unchanged so long as $t < C$. As long as the number of people among which monitoring costs are distributed is much larger under a mandatory system than under a voluntary one, even the case when total monitoring costs are higher with the mandatory system may not change this assumption.

or paying a lower price for their products (lower than c_u). This type of direct punishment by consumers may be the same under both systems or may be possibly larger under the mandatory one if cheating in a mandatory system is seen as worse than in a voluntary one. If the assumption $F^m \geq F^v$ holds, we obtain $\gamma^{v*} \geq \gamma^{m*}$ which reinforces our assumption in the previous sections that $t < C$ and our results continue to hold.