Welfare Measures and Mandatory Regulation for Transgenic Food in the European Union: A Theoretical Framework for the Analysis

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Abstract

This paper presents an analytical framework for studying the impact of mandatory labelling regulation for transgenic food. We compare Genetically Modified (GM) and conventional crop markets and identify gains for food processors prior to mandatory labelling and losses after this measure for the GM market. Nevertheless, food processors could obtain gains for conventional products after market disgregation. Finally, consumers will be worse off both for conventional and GM foods unless qualities other than changes to prices are considered.

Key words: welfare, mandatory labelling, transgenic, Genetically modified organism, European Union policy

JEL: Q18, K32, D62

1 Introduction

Mandatory labelling regulation for transgenic food has been adopted in recent years for the European Union (EU) following environmentalists' and consumers' concern about Genetically Modified Organisms (GMO).

This controversial public policy response could be economically justified if it were expected as a result of an increase in the efficiency of the market. Recent studies (Giannakas and Fulton, 2002; Lence and Hayes, 2002; Lapan and Moschini, 2002) show that although agricultural biotechnology innovations have the potential to improve efficiency, some agents can actually be made worse off by the innovation. Two factors could influence the differences in welfare effects of GM technology adoption by regions: a) the relatively high aversion to GM technology in Europe, b) the existence of market imperfections in one or more stages of the supply chain that prevent the transmission of cost savings associated with the new technology to consumers. This lack of price reductions for GM products, is an opportunity for EU institutions to rationalize mandatory labelling.

Nevertheless, the EU has net importer position on some GM industrial crops, like corn. Some criticisms reveal that the EU policy could be maintaining standards of food safety in a way that unfairly discriminates against foreign suppliers. As there are no international food safety standards that really apply to them, concerning GM products, some countries, like those in the EU, invoke the "precautionary principle" which allows the setting of standards provisionally where relevant scientific evidence is lacking. It is therefore argued that this principle is being abused in order to protect less efficient domestic producers from foreign competition (Sheldon, M., 2002).

Besides the view about regulation and its effects, holding that governments should and can regulate in order to correct market failures and increase welfare, there is the opposite view that various interest groups are affected differently by regulation. These interest groups compete to influence legislation and capture a regulatory body (G. Stigler, 1971)[1].

The main aim of this paper is to present an analytical framework for the evaluation of the welfare effects of the EU policy relating to Labelling GMO in the Agricultural Sector, for consumers and other actors in the agrifood chain: European manufacturers and farmers. By identifying the distribution of gains and loses, we will evaluate whether the government intervention through regulation is economically justified.

Identifying the costs and benefits of regulation is not a simple task, as it involves diverse actors in the agro-biotechnology chain, all invocating their own rights and social interests. At the beginning of the chain, the joint activity of agro-biotechnology enterprises together with public research institutes and universities are responsible for the generation of knowledge. The diffusion of innovation in the form of a new ge-

[1]The interest group theory is a generalization of the capture theory of the Chicago School of Economics. In this interest group theory either firms or consumers can capture a regulatory body and subvert the purpose of the law.

netically modified seed variety is conducted by seed companies, usually multinational enterprises[2]. Once farmers adopt the biotechnology input, this is finally processed by manufacturers who are commercialized in the domestic market and the products are either consumed by European citizens, or exported. Each of these market participant decisions affect each other, e.g. negative public attitudes in the EU towards transgenic foods which imply health and environmental risks, influence not only the rate at which differentiation occurs in the market, but also that at which new technologies are adopted by farmers and to what extent innovations occur in the biotechnology firms. In the same way, government regulatory actions at each stage, -which continue to advance along with advances in biotechnology in the EU.-, play an important role in allocating costs and benefits of biotechnology innovations among agents.

Section 2 develops the recent changes in the European markets and legislation concerning GMOs. Section 3. describes the theoretical framework. Finally, we present the conclusions.

2 Background

Consumer concern about Genetically Modified (GM) products may be expected to affect consumption decisions and to influence the public policy response demanded by consumers. In Europe, Eurobarometer surveys[3] reveal that public expectations of non-medical biotechnology are moderate and are heavily influenced by the social values and ethics of citizens . Nevertheless, there are large diversity in public opinion at the national level on the use of genetically GM for meat products or crops. When asked specifically to what extent they would approve of growing meat from cell cultures so that we do not have to slaghter farm animals, more than one in two conveys their opposition.

In addition, price-reduction benefits from biotechnology seem minor to consumers in the EU, while unknown dangers are exacerbated, both by a lack of information and doubts about the ability of governments to regulate the safety of the food supply. Several cases, with dramatic consequences for the European citizens, such as the scare involving mad cow disease in Great Britain, dioxine poisoning in 1999 in Belgium and listeria in cheese products in France in 2000, have increased the level of awareness and information on public health safety of European consumers.[4]

[2]See Fernández Díez M.C.and Corripio Gil Delgado M.R. (2004)

[3]Eurobarometer 58.0 "Europeans and Biotechnology in 2002" (2nd Edition: March 21st 2003) George Gaskell*, Nick Allum and Sally Stares http://europa.eu.int/comm/public_opinion/archives/eb/ebs_177_en.pdf

Special Eurobarometer 225. Social Values, Science and Technology, June 2005 http://europa.eu.int/comm/public_opinion/archives/ebs/ebs_225_report_en.pdf

[4]Huffman,W.E. et al. (2003) present an alternative explanation for Europeans negligible demand for GM foods: NGOs, largely Greenpeace and Friends of the Earth, have been more prevalent there than in the US, disseminating larger amounts of negative GM-information, and creating skepticism

As a result, some food retailers and manufacturers have moved quickly to establish voluntary standards and labels relevant to their own market situation. Voluntary standards have been set to zero or near zero tolerance for biotechnology products leading to "non-GMO" or "GMO-free" claims. If voluntary GM-free or non GMO labels become standard, in this way, mandatory labels and thresholds could become practically irrelevant (Kalaitzandonakes, 2000). As a result, mandatory biotechnology labelling has been questioned and qualified as an unwise policy[5]. Why would EU governments also decide that information about GM products should be labeled?. Economic theory justifies the "consumers' right to know" when the market does not supply enough information to allow consumers to make consumption choices reflecting their individual preferences (asymmetric or missing information). In this sense, the market does not work efficiently and social costs and benefits may suggest a different labelling outcome than the one resulting from a private firms' labelling decision.

If GM products have been considered a negative attribute for European consumers, that is, a "strictly inferior" product as compared to the traditional counterpart products, and the superior product cannot be distinguished from the inferior one, there will be a problem of asymmetric or missing information. In this situation, producers possess knowledge of relevant information about the product that consumers do not –asymmetric information- (e.g. contains GMOs) or the market information does not exist or is contradictory – imperfect information- (e.g. health consequences of consumption). In these cases Akerlof demonstrated in 1970 in the "lemons" model, that regulation may be desirable to maintain product diversity[6]. In our case, GMO products and GMO free products. Government intervention could also reduce producers incentives by offering too high a proportion of low quality products. Mandatory labelling would address this information problem.

First generation of Agrobiotechnology products refer to GM crops that increase yield or reduce costs for farmers -e.g. improve crop resistance and tolerance to unfavorable weather and environmental conditions (reducing risk) or enhance environmental quality (reducing pesticide use). These characteristics cannot be observed by consumers, and are credence attributes (Nelson , 1970)[7]. GM products could be

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and doubt about GM technology.

[5] Conko, Gregory (2002): Eat, Drink and Be Merry: Why Mandatory Biotech Food Labelling is Unnecessary. Cascade Policy Institute, Oregon. This study presents some drawbacks of mandatory labels: could be misunderstood by consumers as a warning about some important difference (when they do not), problems of information overload and costs expected for producers of non-biotech foods, as segregation will occur and every ingredient will need to be tested for "purity" at each step of the production process.

[6] There have been only a few cases where the owners of the GM products have labeled and proactively marketed their products to consumers (Phillips and Corkindale, 2002)

[7] Nelson, P. (1970): "Information and Consumer Behaviour", Journal of Political Economy, 81: 729-754, considered a typology of goods based on the consumers' capability of attributes detection: before consumption (search goods); after consumption (experience goods) and those whose attributes cannot be detected after consumption (credence goods).

First generation applications in agro biotechnology (e.g. crop resistance to plagues) are considered identified as an asymmetric information case, as GM foods contain negative credence attributes for consumers. Labelling (or certification) becomes a way to transform a credence attribute into a search one (Caswell, J. A & E.M. Mojduszka, 1996). But also as an imperfect information problem, there is missing information about potential health and environmental risks for consumers. These long term effects are unknown and scientific opinions differ about their probabilities.[8]

In such a case, the government would require full disclosure of even preliminary or contradictory information, and consumers' greater access to information would result in an increase in the efficiency of the market .

Besides these potential benefits of mandatory labelling for European consumers, this regulation is expected to have relevant effects on other actors involved in the international trade and agrifood chain, see Figure 1.

Exporters of GMO crops to supply food processors and inputs like seeds to the crop market, have been affected by EU restriction on the GM trade. International legal agreements try to prevent these restrictions on international trade.There are only a few international legal agreements setting out the World Trade Organization (WTO) legal framework regarding trade in GM products. But the EU have reinforced the measures applying the protection of human, animal and plant life or health. The Sanitary and Phytosanitary Agreement (SPS) allows countries to adopt their own standards with reference to international trade but these restrictions must be based on science. Measures should not arbitrarily or unjustifiably discriminate between countries where identical or similar conditions prevail and should not be applied in a manner which would constitute a disguised restriction on international trade. The agreement suggests the use of international standards when possible. The WTO establishes that GMO products that pose a scentifically justificable hazard or that are novel may be legitimately subject to a mandatory labelling standard such that at-risk groups or consumers who wish to exercise their right to know about a novel GMO product may identify such products in the marketplace. Yet, a mandatory labelling standard for GMOs that pose no scientifically justificable hazard and that are substantially equivalent to products already in the market place would clearly contravene the non-discrimination principle (Isaac and Kerr, 2003).

Nowadays, in the EU there are fourteen GM plants produced by different companies that have been approved for commercialisation so far. Under Council Directive 90/220/EEC several GMOs were approved for launching on the market, but from 1999 to 2003 no authorisation was given, either pursuant to the previous Directive 1990/220/EEC, or to the present Directive 2001/18/EC. This de facto moratorium on

credence goods, as consumers cannot obviously perceive those gains. Nevertheless, third generation of agrobiotechnology applications (as fat reduction in oil) could be considered as an experience good. In that situation, government intervention through mandatory labelling should not be economically justified.

[8] Advantages and disadvantages of GM technology are explained in Science (1999), Pardey (2002) and Kydd et al. (2000)

the approvals of new GM crops brought into effect by EU governments, claimed the adoption of the precautionary principle by the European Parliament meeting public concerns (environmental impact and public health safety) on the trasngenics. Now that European legislation has been developed (Directive 2001/18/EC[9], Guidelines on co-existence[10], Regulation (EC) 1830/2003[11] and Regulation (EC) 1829/2003[12]) the moratorium has been lifted and a new variety has been approved to be imported[13].

However, farmers' decision making on whether or not to adopt GM technology is also influenced by the current social, economic and political climate.

Domestic farmers in the EU will be induced to adopt the new technology depending on several factors like public acceptance of GMO. Through the demand of food processor enterprises which reflect consumers' attitudes to GMO, farmers will be induced to apply conventional technology, instead of GM seed. Reluctant consumers of GMO will reduce possible GMO crop uses and GM crops will continue to be focussed on animal feed. Some studies reveal that the adoption and difusion of technology in Europe vary by trait and crop (Gómez Barberó, M. and Rodriguez Cerezo, E., 2004). The adoption will be greater if farmers have a clear view of the potential benefits and if the demand for GM food is guaranteed. In addition, the use of the biotechnology will be more widely spread if the pest pressure is stronger. Bt maize and Ht soybean, reduce the use of pesticides, but benefit depends on infestations level. If the avoidance losses of the infestation are lower than the fee paid by GM seed, farmers will not adopt it.

In other countries, recent data evidence shows a high rate of adoption, especially in the US, Canada and Argentina, thus reflecting growing acceptance of transgenic crops by farmers using the new technology. Genetically modified varieties are planted in 16 countries around the world by 6 million farmers. During the period from 1996 to 2003, the global area of transgenic crops increased 24 fold, from 2.8 million hectares in

[9] Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC-Commission Declaration.

[10] Commission Recommendation of 23 July 2003 on guidelines for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming (notified under document C(2003) 2624.

[11] Regulation (EC) No. 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organims and the traceability of food and feed products produced from genetically modified organims and amending Directive 2001/18/EC.

[12] Regulation (EC) 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed.

[13] Commission Decision of 19 July 2004 concernning the placing on the market of Maize product (Zea mais L. line NK603) genetically modified for glyphosate tolerance). Notified under document numberC(2004) 2761. (2004 643/EC).The authorization today covers the specific use of this maize for feed. The product may be used like any other maize, with the exception of cultivation and uses as or in food.

1996 to 67.7 million hectares in 2003 (cf. ISAAA, 2003). By type of crop, industrial crops are relatively more important, so GM maize, cotton, soya and colza increased the arable area in 2002. In fact, GM soya represents 50% of soya arable land in the world.

In the EU the agricultural landscape has rapidly been changing rapidly towards industrial crops in recent years. There has been a rise in conventional industrial crops that grew by a factor of nearly five between 1975 and 1997. Although this specialization potentially benefits GM farmer adoption, other factors, like the previously mentioned relatively strong aversion to GM technology, together with the lack of price reduction due to market imperfection, could prevent GM wider use among farmers. In this sense, consolidation in the European seed industry is revealed by important changes that have been taking place among agrobiotechnology companies, such as company mergers. The most important mergers include the forming of Syngenta (by Novartis and Zeneca Agrochemicals) in the year 2000, the Merger by Pioneer Hi-Bred International with Dupont in 2002, as well as the acquisition of Aventis Crop Science by Bayer in 2002. (Lheureux, K., M. et al. 2003).

Two factors may have accounted for this consolidation in the European seed industry: a) the combination of R&D in novel biotechnology techniques in agricultural applications by firms with prior experience in industrial chemicals; and b) acquisitions representing efficient instruments of obtaining the smaller firms' intellectual property and know-how, this being simpler than replication.

Although this concentration in agrifood biotechnology does not mean lack of competition, the resulting industry might not operate efficiently due to price distortions. On the one hand, these monopolistic firms are capable of charging monopoly rent, extracting a part of the total static social welfare. On the other hand, Schumpeter (1942) shows that the monopolisation may increase long term social welfare through an increased rate of investment in R&D. Demont and Tollens (1999) suggest that although extremely high adopting rates of biotechnology groups in the US reflect that farmers are clearly receiving some benefits, this picture can not be extrapolate to the EU.

To sum up, this lack of price reductions for GM products, in addition to the relatively high aversion to GM technology in the EU could result in welfare losses for consumers, and the desirability of mandatory labelling by consumers grows.

However, public intervention through regulation could be considered justified when these legal instruments contribute to increases in social efficiency, although allocation of benefits will necessarily occur. Some firms hold the view that the cost of proactively segregating and labelling GMO products exceeds consumers' willingness to pay (Phillips and Corkindale, 2002). In the next section we analize theoretically the implications of mandatory labellling regulation for the different agents in the agrifood chain

3 Theoretical Framework

We will consider two scenarios before and after the mandatory labelling regulation. Different agents involved in the agrifood chain are taken into account:

a) In the first stage, biotechnology firms are responsible for supplying seed to farmers (both conventional and genetically modified seeds). Prices are determined by these two inputs in the seed market. As both goods are imperfect substitutes, relative price changes will affect farmers' demand. In addition, market structure will influence price determination. In this way, the seed industry, including biotechnology firms, is concentrated, and has increased its market power by merging. We will assume a monopolistically competitive market structure.

b) In the second stage, the crop market faces farmers, as suppliers, and food processors, who demand these two types of crops (conventional or genetically modified crops) as inputs in their production process. We will assume a competitive market structure.

c) Finally, the third stage represents the final food market, which includes consumers and enterprises supplying conventional or transgenic foods. Here the hypothesis of competitive market is also applied.

In each of the three markets we will determine prices (seed prices, crop prices and food prices) for conventional (Ps, Pc, Pf) and genetically modified products (Psg, Pcg, Pfg) and quantities (Qs, Qc, Qf, and Qsg, Qcg, and Qfg, respectively). Discrepancies in the conventional and GM products will lead to differences in the evolution of prices, thus affecting relative welfare of each agent in the agrifood chain. These welfare implications will depend on the regulatory scenario considered.

Firstly, we describe the situation prior to the enforcement of labeling regulation.(See figure 2).

I) Biotechnological firms research and develop GM seeds, modified to express a particularly useful agronomic trait. As a result of the technological change, farmers may reduce cost of production or increase yield. These efficiency gains are reflected in their production functions, which shift to the right for the adopter farmers. The demand for genetically modified input, as a value of the marginal productivity, also shifts to the right. In a competitive market, this technological change would mostly affect the crop quantities supplied by farmers. But, considering the monopolistic structure of biotechnology enterprises (supply seed curve is less flat) , the impacts of innovations would induce a higher increase in the modified seed prices (P_{sg}). The prices of innovations in turn affect its adoption and, as a result, reduce crop supply. Consequently, European farmers will be induced to use GMOs if there is a change in the marginal cost of producing the crop either using GMOs or using existing technology. Possibly, in other countries, the lack of strong intellectual property protection results in considerable benefits for farmers through adopting GMOs, by a reduction in price for seed and then a profit advantage. But, in the EU, with effective property rights, the owner of the GMO is a monopolist , and the gross margin using existing technology would be higher than the farmers' gross margin using GMO technology. Thus, the farmers would rationally remain with the old technology, making the spread and adoption of GM technology minor.

II) If the prices of improved inputs increase, the relative prices of conventional seed will be lower. Farmers would prefer to maintain the conventional input (or refuse to adopt new technology), and the demand curve for conventional seed will shift to the right, increasing both quantities and prices of conventional seed. The less competitive the market hypothesis, the higher the increases in prices.

III) We could expect some increase in seed quantities, and the crop supply will shift to the right, reducing crop prices, both for conventional and genetically modified markets. Changes in relative prices between conventional and GM crops will also shift to the left the demand curves in this crop market. So if markup for GM seeds allows for a supply expansion of modified crops, and this in turn to relative lower GM crop prices, demand for conventional crop will shift to the left.

Nevertheless, some agricultural products, like sugar, are heavilly protected in the EU, implying that these market interventions distort the flow of benefits from biotechnology R&D in agriculture. Dermont, M. & Tollens, E. (2004) show that since minimum beet prices are fixed, no important declines are possible. As a result, the benefits essentially flow to farmers without affecting processors. If no domestic prices declines are expected by the introduction of the technology, EU consumers will not gain from the innovation.

IV) In the food market, crops constitute an input in the food process of agrifood companies. A possible price reduction in crop prices shift the supply function of these firms to the right, so allowing for a reduction in prices. Under perfect competition in the market, this effect will reflect a high reduction in food prices. In addition, as transgenic food and conventional food are substitutes, and consumers are not able to distinguish the production process technology, the demand functions will reflect changes in relative prices. In this sense, reduction in GM food prices will turn into a decrease in conventional food demand (the conventional demand function shift to the left) and viceversa.

In this first scenario we have not considered increase in costs due to market segmentation. Adoption of GM crops in some countries, like the EE.UU. and Canada, has been so widespread that the bulk handling facilities that had earlier been set up for non GM crops are now used primarily for GM crops. This means that non-GM crops must now be handled in a way that preserves identity and which is significantly more expensive than the bulk handling system (Lence and Hayes, 2002) As identification costs increase with the share of GM grain it would be expected to be higher in the near future.

In addition, although we could observe reduction in food prices, consumers will not be able to distinguish between GM and conventional food, they choose to observe only changes in prices. But some consumer preferences trying to reduce risks (safety and environmental) are not considered, and would reduce welfare effects. Voluntary labelling goes to market segmentation and could inform the consumers. However, competitive firms will not consider labelling GM products as this is assumed to be a negative attribute for European consumers. Problems of asymmetric information could emerge. Mandatory labelling regulation tries to solve this efficiency problem. In the second scenario we will study the changes in prices resulting from the technological change, relative price changes and also emerging costs, such as identity perservation costs (storage), labelling, testing and certification. (See figure 3).

I) The consideration of these additional costs tend to increase input and output prices. Crops and food supply curves will move to the left. This, partially, compensates, for the reduction in prices induced by technological change.

II) In addition, consumers' preferences towards conventional food would be reflected in an increase of the food demand, and so in prices. Finally, the increase in the demand of conventional food will reduce GM food prices.

III) In conclusion, as a result of this policy, reduction in prices (assuming perfect market competition) will not continue. There will be forces which push the prices in opposite directions (labelling costs and consumers' preferences towards GM free food). Carrying out this expensive policy (increasing costs and prices) will depend on the possibility of compensating for these welfare losses. Next, we will examine the welfare effects for farmers and food processors. Then, we summarize gains for consumers.

3.1 Crop Market

We will focus on the farmers and producer welfare measure changes as a result of the mandatory labelling regulation. European regulation will noy only affect final food production, but also the input market. Genetically modified seeds represent a relevant input for farmers production. Although farm-level evidence suggests that intermediate consumption and seed and plant costs represent just 6.8% of the total input cost in European agricultural enterprises, (in the year 2000, The Farm Accountancy Data Network), the adoption of GM crops by farmers reduces the costs of production by improving agronomic properties, such as herbicide tolerance and resistance to particular insect pests. Innovations affect the production process in different ways. First, GM crops technology impact on the product quantity, increasing plant resistance to insects or tolerance to certain herbicides, and, hence, indirectly on the unit cost. [14]

Nevertheless, Spain is the only country in the EU where any significant amounts of GM crops are grown (about 32.000 hectares of Bt maize). In this respect, European GM adopter farmers are not significant yet, partly because of the monopolist market power of the biotechnology industry. But also, market segmentation implies addi-

[14] A study by Fernández Cornejo et al. (2003) reveals that the adopter of GM cotton and soybean did so mainly to increase yields through improved pest control, secondly to decrease pesticide costs, thirdly to increase planting flexibility, and finally because of combined reasons.

tional costs, identity preservation costs, due to the requirements for keeping, storing and shipping GM seeds separately from traditional varieties to avoid contamination. In addition, mandatory labelling will provoke increases in this input price, as a result of testing and certification costs to garantee GM free products, for both GM and conventional seeds.

Suppose that the farmer uses only a single variable input, seeds. We will first consider in this simple framework the change in productivity (z)as a result of these biotechnological innovations and changes in the output prices (p_{cg}) together, for the farmers adopting GM technology in Europe. Then we will examine the effects on the conventional farmers which should compensate for the increases in conventional seed prices. Finally, we will add the increases to the marginal costs as a result of the segregation and mandatory labelling regulation.

3.1.1 GM crop market ex ante mandatory labelling

Productivity changes and output changes in the GM crop market Let q_{cg}denote the quantity of genetically modified crop produced by European farmers and p_{cg} the prices in the European market for the genetically modified crops. D represents the demand for these crops by the food processors industry in Europe. S stands for the farmers' supply for GM crops, which will shift to the right as a result of the productivity increases. The welfare effects of the introduction of GM crops for the processing industry will be the gain area $b+c+d$ (from area a to area $a+b+c+d$). Adopters farmers surplus is the area $b+e$ before innovation and area $e+f+g$ after innovation. So the gain for innovating farmers (or loss if negative) is the area $f+g-b$. If $f+g>b$ innovator farmers gain. Otherwise they will lose. Net gain will be $c+d+f+g$.

Here Figure 4.

Formally, adopter farmers changes of welfare could be measured by Compensation Variation (CV) or Producers Surplus (PS) changes as a quasirent (R) changes:

$$CV = PS = R(p_{cg}^1, z^1) - R(p_{cg}^0, z^0) =$$
$$\int_{p_{cg}^0}^{p_{cg}^1} \frac{\partial R}{\partial p_{cg}} dp_{cg} + \int_{z^0}^{z^1} \frac{\partial R}{\partial z} dz = \int_L \theta(p_{cg}, z) dp_{cg} - \ell(p_{cg}, z) dz =$$
$$\int_{p_{cg}^0}^{p_{cg}^1} \theta(p_{cg}, z^0) dp_{cg} - \int_{z^0}^{z^1} \ell(p_{cg}^1, z) dz \qquad (1)$$

Where z^0 in the previous expression (1) represents the inital technological situation before the adoption of GM seed. Now we introduce the changes in the food processors' demand as a result of the relative changes in conventional crop prices.

We will expect increases in GM seed to turn to demand for conventional seed and also increases in prices (see figure 2). As GM seed is supplied by a monopolistic seed industry we could consider higher increases in GM than in traditional seeds. It could affect conventional crop supply by farmers in the crop market that will be shiftted to the right as an increase in p_{sm} related p_s .This could reduce $p_c$and, it so, contract GM demand by food processors. If D in the GM crop market shifts to the left, net welfare gain will be reduced. We have described this effect in Figure 5. Welfare effect for food processors will be the gain $b+c+d-a'$ (from area $a+a'$ to area $a+b+c+d$), $<$ $b+c+d$ obtained previously (Figure 4). Welfare effects for innovators farmers will also be reduced . Before innovation farmers surplus will be $b+b'+e$, and after technological change $e+f+g$, resulting in a welfare effects area $f+g-b-b'$.Net gain will be $c+d+f+g-a'-b' < c+d+f+g$ obtained previously.

In addition, monopoly power could also contribute to reduced farmers'welfare gains. Hence, the higher the market power of biotechnology industry to increases p_{sg}, the lower the shift of the farmers' supply as a result of increases in productivity and quantities of crops production ($q^0_{cg}$to q^1_{cg}).

3.1.2 Conventional Crop Market ex ante mandatory labelling

Changes in relative prices Let q_c denote the quantity of conventional counterpart crop produced by European farmers and p_c the prices in the European market for the conventional crops. D represents the demand for these crops by the food processor industry in Europe. S is the farmers' supply for conventional crops, which will shift to the right as a result of changes in relative prices. As we showed in Figure 1, we may expect that due to the increase in GM seed prices, the relative prices of conventional seed will be lower.

The results are similar to the GM crop market. Welfare effects as a result of the innovation process in the conventional crop market for the processing industry will be the gain area $b+c+d$ (from area a to area $a+b+c+d$). Farmers who remain with the old technology surplus is the area $b+e$ before changes and area $e+f+g$ after GM introduction. So, the gain for traditional farmers (or loss if negative) is the area $f+g-b$. If $f+g > b$ traditional farmers gain. Otherwise they lose. Net gain will be $c+d+f+g$. As in the GM market, changes in the Demand position to the left as a result of reduction by processor industry would be expected if GM crop prices decrease.This change will reduce net gains.

3.1.3 GM and conventional crop markets after mandatory labelling regulation

With mandatory labelling, possible reduction in crop prices will be compensated for an increase in identification and preservation costs. Those costs would affect both GM and conventional crops, as we describe in figure 3. However, if share of GM crops increases in the EU in the future, only farmers who intend to receive a premium by selling GM free products (or less than 1% of GM crops) will have to pay those costs. Nowadays, as EU farmers mainly produce conventional crops, identification and preservation costs increase marginal production costs of exporters to the EU. At present, only Spain has a significant share of landcrop maize with GM seeds. We will expect these costs to affect domestic farmers in the near future with the hypothesis that the adoption of the new technology will be generalized.

Figure 6 shows that the welfare effects of the mandatory labelling of GM crops for the processing industry will be the lost area $b+c$(from area $a+b+c$ to area a. Adopter farmers' surplus is the area $d+e+f$ before regulation and area $d+b$ afterwards. So the loss for innovating farmers (or gain if positive) is the area $b-(e+f)$. If $b > e+f$ innovator farmers gain. Otherwise they will lose. Net loss will be $-(c+e+f)$.

Welfare effect will also change as a result of the mandatory labelling legislation. Which of these markets would be more affected depends on the increase of marginal costs in each market. The welfare effect could be measured by the folllowing expression of changes in quasirents:

$$
\begin{gathered}
CV = PS = R(p_{cg}^2, w^1) - R(p_{cg}^0, w^0) = \\
\int_{p_{cg}^0}^{p_{cg}^2} \frac{\partial R}{\partial p_{cg}} dp_{cg} + \int_{w^0}^{w^1} \frac{\partial R}{\partial z} dw = \int_L \theta(p_{cg}, w) dp_{cg} - \ell(p_{cg}, w) dw = \\
\int_{p_{cg}^0}^{p_{cg}^2} \theta(p_{cg}, w^0) dp_{cg} - \int_{w^0}^{w^1} \ell(p_{cg}^1, w) dw \qquad (2)
\end{gathered}
$$

Where w^0 in the previous expression (2) represents the initial marginal cost for the innovator farmer before the segregation of the market, and w^1 includes the identification and preservation costs after the mandatory labelling.

3.2 Food Market

In this section we study changes in the welfare of consumers and food market processors, taking into account both scenarios, before and after mandatory labelling regulation. As we show in Figure 2, in the first scenario, ex ante the implementation of mandatory regulation, welfare effects on crop and food markets are similar, as we could also expect changes in supply due to input prices (in this market, crop is an input to the food processor industry and will be reduced) and changes in demand of consumers as a result of relative prices changes -GM food and conventional food-.In that sense, explanations for conventional and GM crop market before regulation could also be introduced here. (see figure 7).

As far as reduction in food prices is concerned, consumers gain and food processors would reduce their previous gains in the crop market. Net gain will be $c+d+f+g-a'-b'$.As consumers can not differenciate between both types of food, their choice is based on prices and we could not expect changes in demand function due to quality perceptions. Only if voluntary labelling by food processors is generalized, will conventional food demand shift to the right, increasing conventional food prices as we will explain for mandatory regulation.

Figure 3 summarizes the effects on the food market as a result of mandatory labelling. Two principal changes are introduced: increases in the marginal cost of production for food processors and changes in consumer preferences. The former is the result of the identification costs passed from the crop market to the food market. This increase in costs will shift the supply curve to the left, contributing to increases in market prices, both for conventional and GM food. The latter, changes in consumer preferences, is the result of the additional information provided for the food market. If preferences continue to reflect GM aversion, the demand function will shift to the right for conventional food, and to the left to GM food. We describe these changes in the next section.

3.2.1 GM and conventional food markets after mandatory labelling regulation

Figure 8 shows that the welfare effects of the mandatory labelling of GM food for the consumers will be the lost area $b+c$(from area $a+b+c$ to area a). Food processors surplus is the area $d+e+f$ before regulation and area $d+b$ afterwards. So the loss for innovating industry (or gain if positive) is the area $b-(e+f)$. If $b>e+f$ innovator food processors gain. Otherwise they lose. Net loss will be $-(c+e+f)$.

For conventional food we expect a major increase in food prices due to consumer preferences for GM-free food. Figure 8 shows these changes in consumer and producer surplus.

To continue buying conventional food after mandatory labelling implies a welfare effect on consumer and food processors as described in figure 9.

Consumer surplus changes from area $(a+a'+b)$ to area $(a'+b')$, with a net negative effect of $(b\prime-a-b)$ These increases in prices cause a change to the producer surplus form area $(c+d)$ to area $(c+a+e)$, resulting in a net effect of $(a+e-d)$. Higher preferences towards free GM food increase welfare effects on food processors as area $e$will be higher, and relative higher increases in marginal costs from identification costs result in lower gains to food processors, as area d will be higher. Net effect in this conventional food market will be the sum of net effects for consumer and food processors, that is the area: $e+b'-b-d$. This area will represent net gain if changes in preferences increases $b\prime$and $e$in a way that compensates for changes in marginal cost that increases $b+d$.

The following table summarizes net effect in crop and food markets.

Nevertheless, consumer welfare effects should be measured accurately by introducing changes in quality different from changes in prices, not observed and quantified in the food market, as a result of the additional information included on the label after regulation.

4 Conclusions

The social unacceptability of GMO technologies in the European Union (EU) has been considered a factor that foregoes substantial benefits in terms of welfare (Meijl and Tongeren, 2004). In this paper we present a simple framework to explain how mandatory labelling, as an instrument that reflects consumption rejections to GMO technologies, affects the actors in the food chain diferently. Before the mandatory labelling regulation the difussion of GM innovations could have negatively affected consumers' welfare as a result of some important regional economic factors. Consumers would have been worse off due to food prices increases both in conventional and GM food. These higher prices will be the result of a) monopolist power of seed suppliers that prevents the transmission of cost savings and b) European market interventions through Common Agricultural Policy that protects agricultural prices. So, EU consumers will not gain from the innovation. In that scenario mandatory labelling regulation for transgenic food in the EU has been adopted following interest groups' demands, like consumer and environmentalists' associations. But, after mandatory labelling regulation, segregation costs, including identification and preservation costs, also contribute to the increase in prices of conventional and GM products reducing consumer welfare effects. European consumer willingness to pay higher prices should at least be less than the potential benefit result of the gains in efficiency for consumers. So greater access to information (symmetric and perfect information) provided for consumers, justified as a consumers' right to know should compensate for these consumer losses. Otherwise, not including qualities other than changes to prices, reduces welfare for consumers in both transgenic and conventional food.

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FIGURE 1

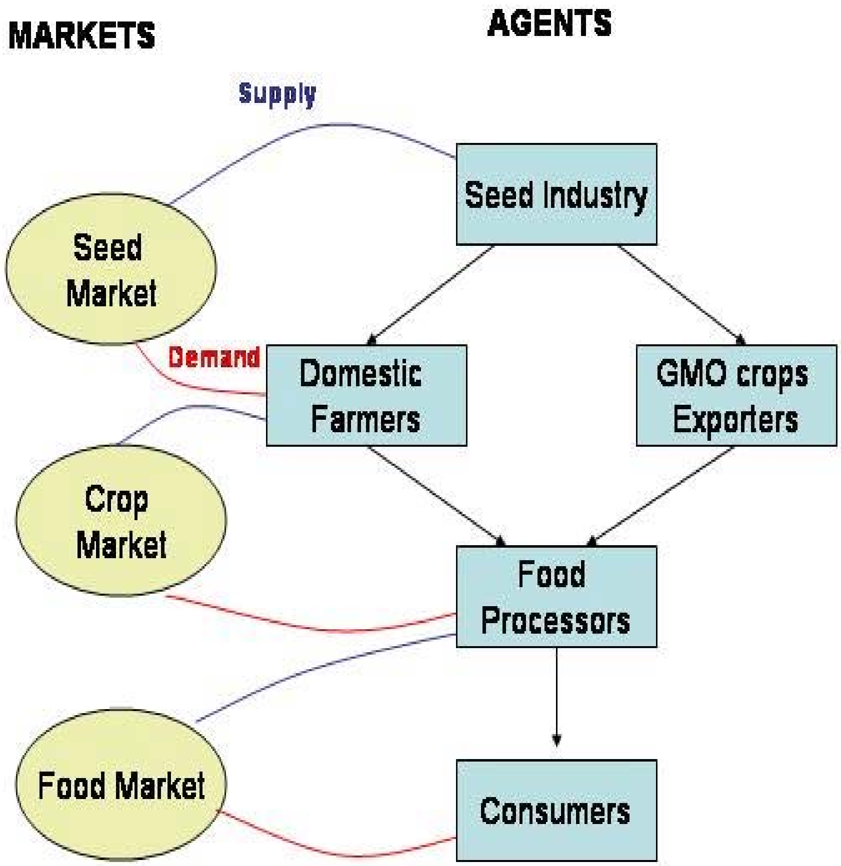

MARKETS
AGENTS
Supply
Seed Industry
Seed Market
Demand
Domestic Farmers
GMO crops Exporters
Crop Market
Food Processors
Food Market
Consumers

FIGURE 2

I) Scenario prior to mandatory labelling regulation

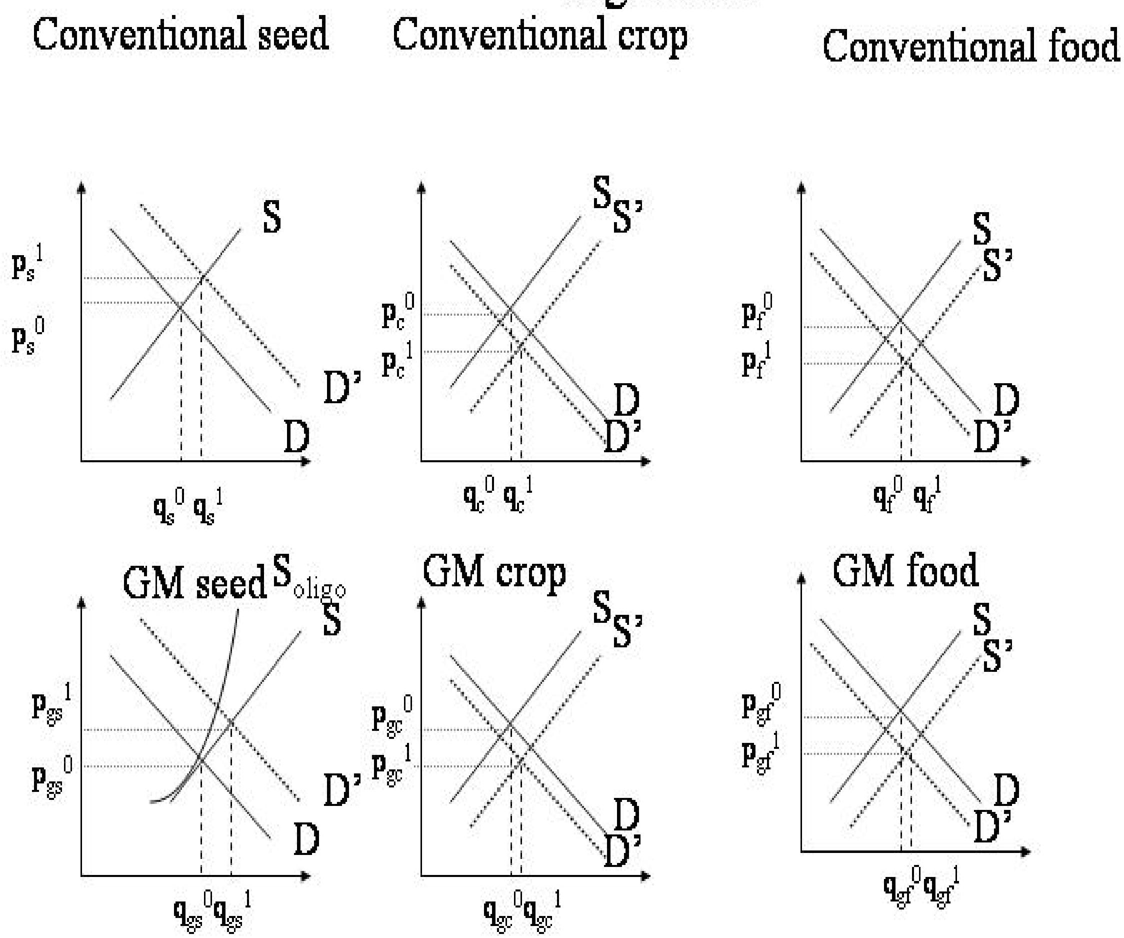


FIGURE 3

I) Scenario enforcement of mandatory labelling regulation

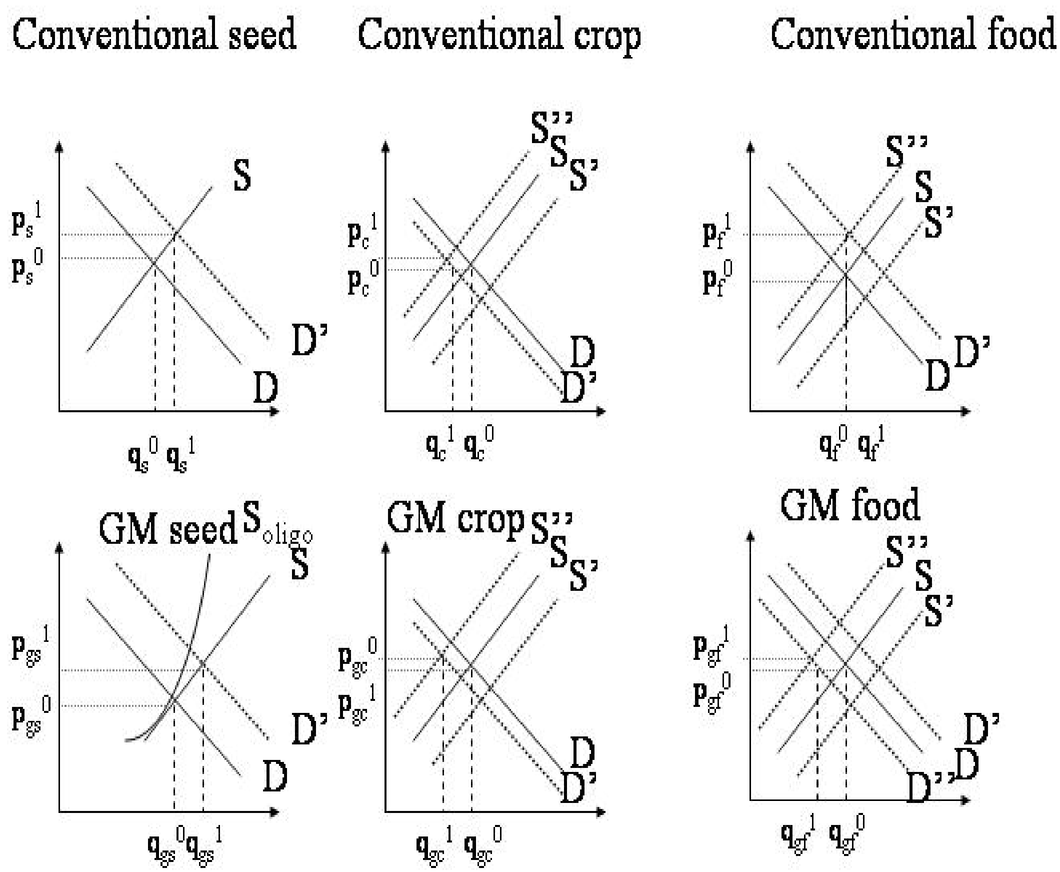


FIGURE 4

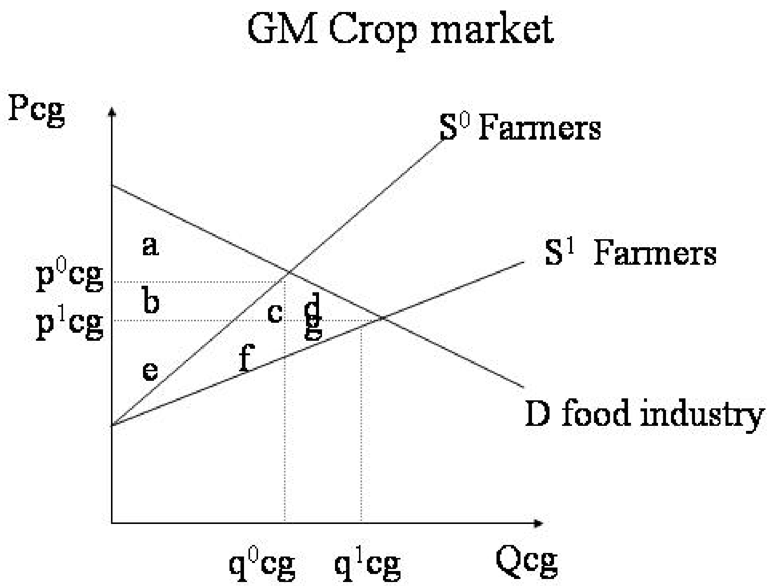

GM Crop market
Pcg
S0 Farmers
S1 Farmers
a
p0cg
b
p1cg
c
d
g
e
f
D food industry
q0cg
q1cg
Qcg

FIGURE 5

GM Crop market

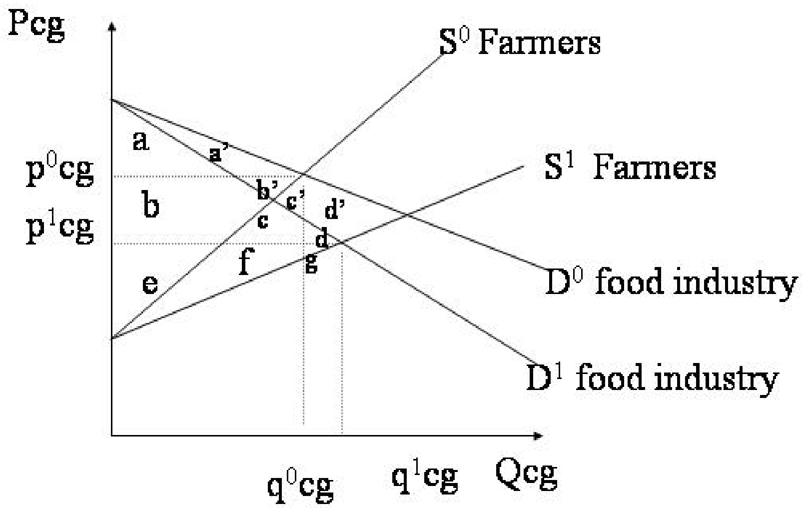


FIGURE 6

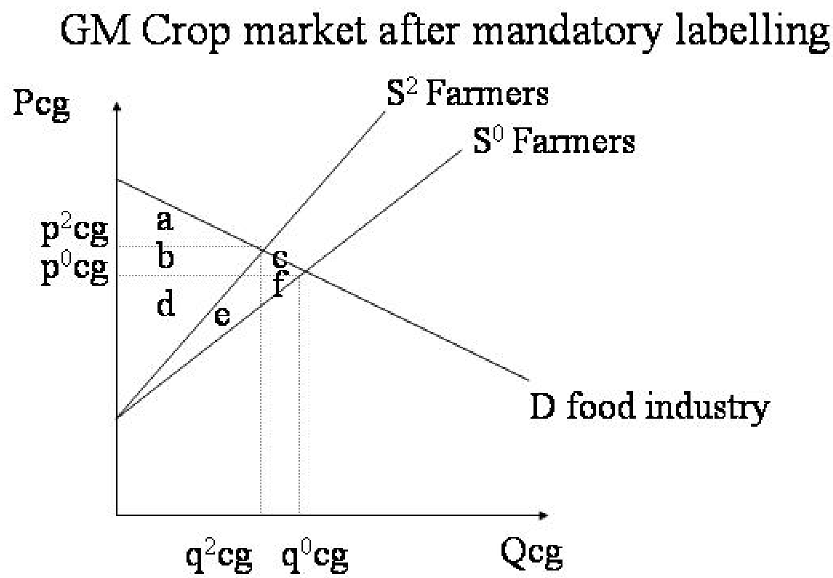

GM Crop market after mandatory labelling
Pcg
S2 Farmers
S0 Farmers
p2cg
p0cg
a
b
c
d
e
f
D food industry
q2cg
q0cg
Qcg

FIGURE 7

GM Food market before mandatory labelling

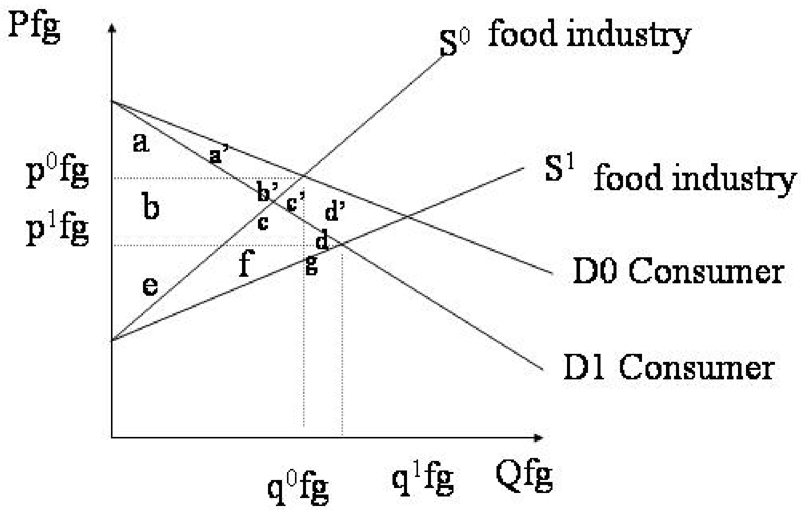


FIGURE 8

GM food market after mandatory labelling

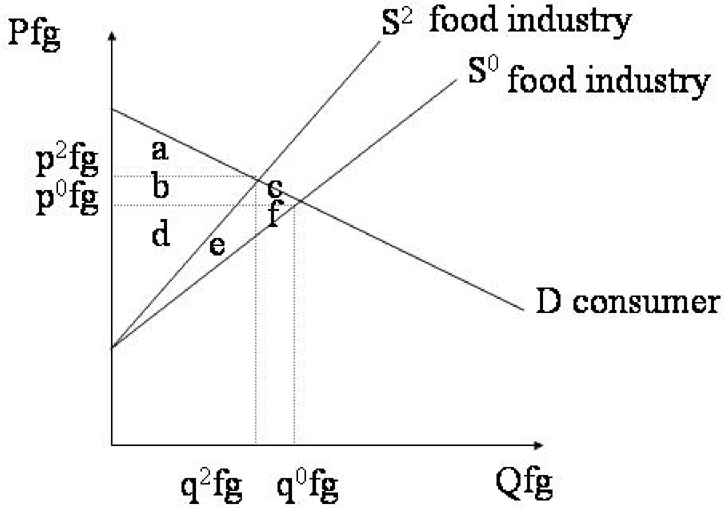
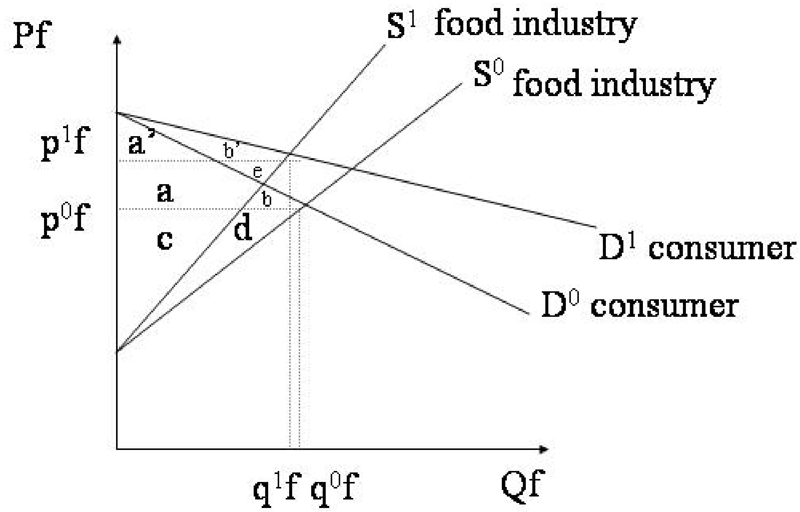


FIGURE 9

Conventional food market after mandatory labelling



	crop market		food market	
	Farmers	Food processors	Food Processors	Consumers
Ex ante				
-GM	gain/loss	gain	gain/loss	gain
-Conventional	gain/loss	gain	gain/loss	gain
Ex post				
-GM	gain/loss	loss	gain/loss	loss
-Conventional	gain/loss	loss	gain	loss