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International Trade in Biotechnology Products and Strategic Mandatory Labelling

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Abstract

This paper examines strategic motives to impose mandatory labelling of biotechnology products when consumers perceive these products as being of lower quality. When a foreign dominant firm produces a biotechnology product, it is shown that without mandatory labelling fringe firms, which produce a conventional product, provide voluntary labelling as long as voluntary labelling is fully credible. Information on which product is biotechnologically engineered is hence completely disclosed without mandatory labelling. An importing country may nevertheless impose mandatory labelling mainly because part of labelling cost can be shifted to the foreign dominant firm. Strategic mandatory labelling, however, is not always protectionist.

Keywords: biotechnology; credence goods; genetically modified food; labelling; strategic trade policy.

JEL classification: F12; F13; L15; Q17; Q18.

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1 Introduction

Rapid advances in biotechnology have caused disputes on trade in agricultural and food products. The recent dispute on trade in genetically modified food (GMF), food containing genetically modified organisms (GMOs), between the United States (US) and other countries such as Japan and the European Union (EU) is an example. Many of the currently available GMOs are aimed at reducing production costs by, for example, making crops resistant to insects through trans-species genetic modification.[1] As unintended by-products, however, it is argued that GMOs may cause allergic responses and may also have long-term negative impacts on human health and on the environment.[2] Because of these negative features, some consumers perceive GMF as lower quality products. In order to deal with imports of these products, some importing countries impose mandatory labelling of GMF.[3]

Importing countries may possibly have two motives to impose mandatory labelling of biotechnology products. The first motive is to protect consumers from unintended consumption of these products. Typically, consumers cannot know whether products are biotechnologically engineered or not, even after they consume these products. Labelling helps consumers to identify biotechnology products. The second and more controversial motive is protectionism. When a biotechnology product is invented in a foreign country and imported, the importing countries may use mandatory labelling as a tool to protect domestic firms or to extract part of the rents the foreign producers earn from the innovation of biotechnology products. Exporting countries of biotechnology products also argue against mandatory labelling because it requires significant costs to producers. If

[1]Examples include Bt-corn, which is resistant to the European corn borer, Bt-cotton, which is resistant to bollworm infestation, and Roundup-ready soybean, which is tolerant to Roundup, a postemergence herbicide. According to James (2001), four major producing countries of GMOs in 2001 are the US, Argentina, Canada, and China. The US is the largest producer of GMOs and shares 68% (35.7 million hectares) of the global areas of GMOs in 2001. Four major crops of GMOs are soybean, corn, cotton, and canola. GM soybean shares 63% (33.3 million hectares) of all GMOs grown in the world in 2001. Furthermore, according to USDA NASS (2000, 2002), 75% (54.8 million acres) of soybeans planted in the US in 2002 are GM type, significantly up from 54% in 2000. 71% (10.2 million acres) of cotton and 34% (26.8 million acres) of corn planted in the US in 2002 are also GM types, up from 61% and 25% in 2000, respectively.

[2]Kerr (1999) provides detailed discussion on features of genetic modification. Chataway and Assouline (1998) discuss in detail potential environmental risks of GMOs.

[3]Mandatory labelling of GMF has been effective in the EU since April 2000 and in Japan since April 2001. Labelling is required for any food containing GMOs above a one per cent tolerance level in the EU and a five per cent tolerance level in Japan.

mandatory labelling is imposed, producers of biotechnology products have to sort and test their products. These costs give disadvantage to producers of these products.[4]

In this paper, I investigate whether the importing country actually has incentives to impose mandatory labelling of biotechnology products for reasons other than consumer protection. In order to examine this issue, I construct a simple partial equilibrium model in which the domestic market is supplied by a foreign dominant firm with fringe firms. I choose this framework because it is one of the simplest cases that allow me to analyze the strategic use of mandatory labelling with relevancy to biotechnology in the agricultural and food sector. In this sector a small number of firms engage in research and development (R&D) in biotechnology and provide biotechnology products. Monsanto is an example of such firms. In this paper, I assume only one firm succeeded in developing biotechnology. The dominant firm has market power because of its cost advantage due to biotechnology. A large number of firms still produce food by using conventional technology.

Domestic consumers perceive the biotechnology product as being of lower quality. Since the perceived quality difference arises from difference in production process, however, it is a *credence* attribute in the terminology of Darby and Karni (1973). That is, without labelling consumers cannot know which product is biotechnologically engineered even after they consume it.[5] Individual firms then may offer voluntary labelling. The domestic government may also want to impose mandatory labelling. In order to focus on the strategic aspects of mandatory labelling, I assume that both types of labelling are fully credible, so that there is no difference in informational value between them, and that unit cost of labelling is the same for both types of labelling.

The main issue is whether the domestic government uses mandatory labelling for protectionism rather than consumer protection. Protectionism is defined as improving domestic welfare at the expense of the foreign country with welfare gain in the domestic

[4] According to KPMG Consulting's (2000) estimates, costs of mandatory labelling of GMF could be equivalent to at least 9 to 10 per cent of the retail price of processed food products. These costs stem from separation of GMOs and non-GMOs at various stages of production, testing and validation to determine the presence (or absence) of GMOs, liability insurance, and so on. The report also suggests that voluntary labelling of non-GMF would be subject to similar cost increases. Another estimates are provided by Commission of the European Communities (2000). The report surveys the literature and argues that costs of mandatory labelling of GMF would be 6 to 17 per cent of the farm gate price of various crops.

[5] Credence goods are distinguished from *experience goods* in the terminology of Nelson (1970). In the case of experience goods, consumers can know quality of those goods after they consume those goods.

country being smaller than welfare loss in the foreign country.[6]

The main results are as follows: If voluntary labelling is fully credible, the fringe firms voluntarily provide labelling when mandatory labelling is not imposed. Information on whether a product is biotechnologically engineered or not is hence completely disclosed without mandatory labelling. Nevertheless, the domestic government may impose mandatory labelling of biotechnology product because it can shift part of labelling cost to the foreign dominant firm by doing so and because the dominant firm extracts extra rents under voluntary labelling. This strategic mandatory labelling, however, is not always protectionist.

In the trade policy literature, while the role of trade policy for products with unknown quality has been examined by several papers,[7] the role of labelling has been rather ignored. Moreover, most of the existing papers examine trade policies for *experience goods* in the terminology of Nelson (1970) and few papers have examined those for credence goods. Bond (1984) is an exception. He examines trade and welfare effects of labelling for products with differentiated but unobservable qualities. The present paper is different from his in two respects. First, while he examines costless labelling only, labelling costs play a crucial role in this paper. Second, he does not examine strategic motive to require labelling, which is the main issue in this paper. In the agricultural economics literature, welfare effects of mandatory labelling have been examined by several works including Bureau *et al.* (1998), Gainsford and Lau (2000), and Plunkett and Gainsford (2000). Strategic motives to impose costly mandatory labelling, however, are not examined by these papers. Furthermore, in the literature of the economics of information, while several papers have investigated the issue of credence goods,[8] most of them have focused on expert services for credence goods and ignored the role of labelling.[9] An exception is Marette *et al.* (2000). In the context of product safety, they investigate effects of labelling, minimum safety standards, and liability enforcement for credence goods as well as for other types of

[6] This definition of protectionism is similar to what Fischer and Serra (2000) define.

[7] See, for example, Donnenfeld *et al.* (1985), Grossman and Horn (1988), Bagwell and Staiger (1989), and Raff and Kim (1999).

[8] See, for example, Darby and Karni (1973), Pitchik and Schotter (1987), Wolinsky (1993, 1995), Taylor (1995), Emons (1997, 2001), Marette *et al.* (2000), and Feddersen and Gilligan (2001).

[9] This is because credence goods have a characteristic that sellers of these goods are also experts who determine the consumers' needs. Medical and legal services and a wide variety of repair services are examples on which the literature is mainly focused.

goods. They show that labelling is potentially a useful instrument for improving market efficiency in the case of credence goods. Strategic aspects of labelling are again ignored.

The remainder of the paper proceeds as follows. Section 2 sets up the model and shows equilibrium under perfect information. Section 3 analyzes equilibrium with and without mandatory labelling. Section 4 examines strategic use of mandatory labelling. Section 5 briefly discusses extensions of the model. Section 6 concludes.

2 The Model

In this section, I develop a simple partial equilibrium model of trade in products which are produced by two different production processes.

2.1 The basic model

There are two countries: home and foreign. In these two countries there are initially a large number of identical firms which produce a homogenous product called "food" denoted by x. All firms are *ex ante* identical in the sense that they use the same production technology, which is represented by the constant unit production cost, c_1. One of the firms in the foreign country has successfully invented a new type of production process called "genetic modification" or GM, which is represented by a lower unit production cost, c_2, where $c_2 < c_1$.[10] The food produced by the GM technology, however, has some negative effects on human health and hence is perceived as lower quality food. In order to distinguish between conventional food or non-GMF and "genetically modified food" or GMF, denote non-GMF by x_1 and GMF by x_2. Assuming that the perceived food quality can be measured in a single dimension, normalize the perceived quality of non-GMF to one and let q be the perceived quality of GMF, where $q \in (0, 1)$. Since the innovation is perfectly protected by intellectual property rights, the foreign firm that invented GM technology can exploit monopoly power over the production of GMF. Since the conventional non-GMF technology is available to any firm, on the other hand, there is free entry to non-GMF producers. Although the supply side is very simple and I ignore

[10] Although the firm that invented the new production process incurs a fixed cost of innovation, it is ignored for simplicity. If the size of cost reduction is independent of the amount of money spent on the innovation, the fixed cost of innovation does not play any role at the stage of market competition because it is already sunk.

the vertical structure in the agricultural and food sector, this simple model is enough for my purpose.[11]

I focus on the home market and consider intervention by the home government only. In the home market, there is a continuum of consumers indexed by θ, which is uniformly distributed on $[0, \bar{\theta}]$ with density one. The parameter θ represents a consumers' marginal willingness to pay for quality of food. Each consumer is assumed to either buy one unit of food or nothing.[12] Consumer θ's (indirect) utility is given by $u = \theta\tilde{q} - p$ if he buys one unit of food of quality $\tilde{q} \in \{1, q\}$ at price $p \in [0, \infty]$. His utility is zero if he buys nothing.

I assume that the process attribute of food is a *credence* one. Labelling can solve the asymmetric information problem. Let $s > 0$ be the unit cost of labelling, which reflects all costs for guaranteeing that the information in the label is true.[13] Firms can voluntarily provide labelling. The home government can also impose mandatory labelling. In order to focus on the strategic aspects of mandatory labelling, I assume that labelling is always fully credible[14] and that the unit cost of labelling is the same for both types of labelling.[15]

As for unlabelled products, I assume that consumers construct a rational belief in the sense that they believe $\lambda \in [0, 1]$ of all unlabelled products are non-GMF, where λ is the actual share of non-GMF in unlabelled products. While consumers cannot see whether

[11] In section 5 I discuss some generalization of the model. For detailed modelling of the food sector, see Moschini and Lapan (1997) and Lapan and Moschini (2000).

[12] While this assumption may sound strange, it can be justified if one unit is interpreted as the amount of a particular type of food consumed in a certain period of time. For example, the amount of breakfast cereals a consumer consumes in a month would be very income inelastic as long as income is above a certain level. As income becomes higher, she would consume higher quality cereals, such as organic cereals, rather than increase the amount of cereal consumption. Thus, one can take the amount of breakfast cereals a person consumes in a month as "one unit." Moreover, if one finds it too expensive to eat cereals for breakfast, she would eat something else. In that case, her demand for cereals could be zero.

[13] These costs include sorting and testing costs and liability insurance as well as direct cost of labels.

[14] Otherwise, the difference in informational value between voluntary and mandatory labelling may become part of reasons to impose mandatory labelling. In the case of credence goods, the standard argument is that voluntary labelling is not credible (e.g., Bureau *et al.*, 1998). However, I assume that voluntary labelling is somehow fully credible. For example, false advertising and consumer fraud laws may prevent firms from providing misleading labelling. Mandatory labelling, on the other hand, can be fully credible if the enforcement is perfect. In section 5.3 I discuss the case in which labelling is not fully credible.

[15] Under mandatory labelling of GMF the dominant firm has to incur the same unit cost of labelling as that of the fringe firm under voluntary labelling. This may be because, for example, the dominant firm produces other biotechnology products that are not permitted to sell in the home country yet. It then may have to sort and test its own products so that these pre-commercial products are not mixed in. Moreover, liability insurance to protect against the risks of damaging products of non-GMF producers through cross-pollination may be considered as part of labelling cost. The vertical structure in the agricultural and food sector, which is abstracted in this model, may also cause significant labelling cost for GMF.

a specific unlabelled product is GMF or not, they know the share of non-GMF in the unlabelled market. When consumer θ buys one unit of unlabelled product, his (expected) utility is given by $u = \theta(\lambda + (1-\lambda)q) - p$.

The game proceeds in three stages: In stage 1 the home government decides whether to impose mandatory labelling of GMF; in stage 2 the foreign dominant firm and the fringe firms simultaneously decide whether to label their own products; in stage 3 the foreign dominant firm chooses price to maximize its profits, each fringe firm maximizes its own profits by taking price as given, and each consumer chooses his consumption to maximize his utility. The solution concept is the subgame perfect Nash equilibrium (SPNE).

2.2 Market equilibrium under perfect information: A benchmark

As a benchmark I examine equilibrium under perfect information. Assuming both GMF and non-GMF are available in the market, there are two critical values of θ: $\theta_1 \equiv (p_1 - p_2)/(1-q)$ and $\theta_2 \equiv p_2/q$, where p_1 and p_2 are prices of non-GMF and GMF, respectively. A consumer with $\theta = \theta_1$ is indifferent between buying non-GMF and GMF. A consumer with $\theta = \theta_2$ is indifferent between buying GMF and nothing. Demands for non-GMF and GMF are given by $x_1 = \bar{\theta} - \theta_1$ and $x_2 = \theta_1 - \theta_2$, respectively.[16] The inverse demands for non-GMF and GMF are respectively given by

$$p_1 = \bar{\theta} - x_1 - qx_2 \quad \text{and} \qquad p_2 = q(\bar{\theta} - x_1 - x_2). \tag{1}$$

Since the supply of x_1 is perfectly elastic at $p_1 = c_1$, the residual demand for x_2 is

$$p_2 = q(c_1 - (1-q)x_2). \tag{2}$$

Assuming positive amounts of both x_1 and x_2 are consumed in equilibrium,[17] the first-order condition (FOC) for the dominant firm's profit maximization yields

$$x_2^p = \frac{qc_1 - c_2}{2q(1-q)}. \tag{3}$$

Then, the equilibrium level of x_1, p_2, and π_2 are respectively given by

$$x_1^p \;=\; \bar{\theta} + \frac{c_2 - (2-q)c_1}{2(1-q)}, \tag{4}$$

[16] I assume that $\bar{\theta} - c_1 > 0$ and $q\bar{\theta} - c_2 > 0$ hold so that if each product is sold at price equal to its unit production cost there is positive demand for the product.

[17] Conditions are $qc_1 - c_2 > 0$ and $2(1-q)\bar{\theta} - (2-q)c_1 + c_2 > 0$. These conditions require that the cost reduction by GM technology is significant, even taking a decrease in perceived quality into account, while non-GMF is not driven out of the market.

$$p_2^p = \frac{qc_1 + c_2}{2}, \quad \text{and} \tag{5}$$

$$\pi_2^p = \frac{(qc_1 - c_2)^2}{4q(1-q)}. \tag{6}$$

Home welfare is measured by the sum of consumer surplus and producer surplus: $W = CS + PS$. As long as the supply of the competitive fringe is perfectly elastic, however, producer surplus is always zero. Home welfare is thus just equal to consumer surplus. In this case it is given by $CS^p = (\bar{\theta} - c_1)^2/2 + (qc_1 - c_2)^2/8q(1-q)$.

3 Equilibrium with and without Mandatory Labelling

In this section, I analyze stages 2 and 3, which can be divided into two subgames. The subgames correspond to the cases in which the home government *does* and does *not* impose mandatory labelling of GMF. I assume that parameters satisfy the conditions which guarantee positive demands for both GMF and non-GMF.[18]

3.1 Stage 3

In stage 3, each firm maximizes its own profits and each consumer maximizes his utility, taking labelling choices of firms as given.

There are six typical cases in stage 3:[19] (1) The dominant firm labels and all fringe firms also label (denoted by (L, L)); (2) The dominant firm labels and no fringe firm labels (L, NL); (3) The dominant firm labels and some fringe firms also label, while the other fringe firms do not label $(L, L\text{-}NL)$; (4) The dominant firm does not label and all fringe firms label (NL, L); (5) Neither of the dominant firm nor fringe firms label (NL, NL); (6) The dominant firm does not label and some fringe firms label, while the other fringe firms do not label $(NL, L\text{-}NL)$.

Case 1. (L, L): Since both products are labelled, conditions are the same as those under perfect information, except for labelling costs. Due to labelling, unit production

[18] These conditions are (i) $\bar{\theta} - c_1 - s > 0$, (ii) $qc_1 - c_2 - s > 0$, (iii) $2q\bar{\theta} - qc_1 - c_2 - s > 0$, and (iv) $2(1-q)\bar{\theta} - (2-q)c_1 + c_2 - (2-q)s > 0$. Basically, these conditions require that s is not so high and that q is within a certain range.

[19] Since there are a large number of fringe firms, there actually exist many cases. However, for the purpose of the analysis in this paper, it is enough to distinguish these six cases.

costs are replaced by $c_2 + s$ and $c_1 + s$. The dominant firm's profits are given by

$$\pi_2^{LL} = \frac{(qc_1 - c_2 - (1-q)s)^2}{4q(1-q)}. \tag{7}$$

A representative fringe firm earns zero profits.

Case 2. (L, NL): Since consumers believe that unlabelled products are all non-GMF, i.e., $\lambda = 1$, the inverse demand functions are the same as those under perfect information (Eq. (1)). Since the supply of x_1 is exactly the same as that under perfect information, the residual demand for x_2 is also the same as that under perfect information (Eq. (2)). Labelling increases the dominant firm's unit production cost by s. Then, the FOC for the dominant firm yields $x_2^m = (qc_1 - c_2 - s)/2q(1-q)$. The equilibrium level of x_1 is given by $x_1^m = \bar{\theta} + (c_2 + s - (2-q)c_1)/2(1-q)$. It is shown that x_1 is higher and x_2 is lower in this case than under perfect information.

The equilibrium level of p_2 is given by $p_2^m = (qc_1 + c_2 + s)/2$, which is higher than p_2^p (Eq. (5)) only by $s/2$. This implies that the dominant firm pays part of labelling cost. The reason is as follows: Since the slope of the marginal revenue curve is steeper than the slope of the inverse demand curve, when the unit production cost increases by s the dominant firm finds it optimal to increase p_2 by less than s.

The dominant firm's profits in this case are lower than under perfect information:

$$\pi_2^m = \frac{(qc_1 - c_2 - s)^2}{4q(1-q)} < \pi_2^p. \tag{8}$$

Consumer surplus in this case is given by

$$CS^m = \frac{(\bar{\theta} - c_1)^2}{2} + \frac{(qc_1 - c_2 - s)^2}{8q(1-q)}. \tag{9}$$

Case 3. $(L, L\text{-}NL)$: As in case 2, since GMF is labelled, consumers believe that unlabelled products are all non-GMF, i.e., $\lambda = 1$. Thus, while some non-GMF are supplied with labelling, demand for the labelled non-GMF is zero because no one buys non-GMF at a labelling-cost-inclusive higher price. The equilibrium outcome is the same as that in case 2, except for the existence of the supply of labelled non-GMF with zero demand.

Case 4. (NL, L): Since consumers believe that unlabelled products are all GMF (i.e., $\lambda = 0$), the inverse demand functions are the same as those under perfect information and hence are given by Eq. (1). Since the supply of x_1 is perfectly elastic at $p_1 = c_1 + s$, the residual demand for x_2 is given by $p_2 = q(c_1 + s - (1-q)x_2)$. The FOC for the foreign

dominant firm yields $x_2^v = (qc_1 + qs - c_2)/2q(1-q)$. The equilibrium level of x_1 is given by $x_1^v = \bar{\theta} + \{c_2 - (2-q)(c_1+s)\}/2(1-q)$. It is shown that x_1 is lower and x_2 is higher in this case than under perfect information. The equilibrium level of p_2 is given by

$$p_2^v = \frac{q(c_1+s)+c_2}{2}. \tag{10}$$

It is obvious that p_2^v is higher than p_2^p (Eq. (5)) by $qs/2$. The increase in p_1 due to labelling cost allows the dominant firm to charge a higher price for its product and to earn higher profits than under perfect information, i.e.,

$$\pi_2^v = \frac{(q(c_1+s)-c_2)^2}{4q(1-q)} > \pi_2^p. \tag{11}$$

For the home country, consumer surplus in this case is given by

$$CS^v = \frac{(\bar{\theta}-c_1-s)^2}{2} + \frac{(q(c_1+s)-c_2)^2}{8q(1-q)}. \tag{12}$$

Case 5. (NL, NL): When no firm provides labelling, consumers cannot distinguish between GMF and non-GMF. Thus, the same price must be given to both products. The dominant firm chooses price to maximize its own profits by taking the perfectly elastic fringe supply at $p = c_1$. Since the fringe supply is zero for price below c_1, the dominant firm monopolizes the market if the monopoly price is less than c_1. Consumers know that the fringe firms never supply non-GMF at price below c_1, which implies that demand for food at price below c_1 is just the demand for GMF, i.e., $x = \bar{\theta} - p/q$. The monopoly price is given by $p^M = (q\bar{\theta} + c_2)/2$. Thus, the dominant firm charges this price if $p^M < c_1$.

If $p^M \geq c_1$, then the dominant firm sets price just below c_1 by a very small amount $\varepsilon > 0$, so that no fringe firm has an incentive to supply non-GMF. Otherwise, the dominant firm faces the perfectly elastic fringe supply at $p = c_1$. The dominant firm's price choice is then given by $p^{NL} = \min\{(q\bar{\theta} + c_2)/2,\ c_1 - \varepsilon\}$. In either case, the dominant firm monopolizes the market and only GMF is supplied. Note that while consumers construct a rational belief on the share of non-GMF in unlabelled products, the fringe firms cannot share the market because of the market power of the dominant firm.

Here I focus on the case where the dominant firm can charge the monopoly price, i.e., $q\bar{\theta} - 2c_1 + c_2 < 0$.[20] The outcome is then $p = (q\bar{\theta} + c_2)/2$, $x_1 = 0$, $x_2 = (q\bar{\theta} - c_2)/2q$, and

$$\pi_2^M = \frac{(q\bar{\theta}-c_2)^2}{4q}. \tag{13}$$

[20]Including another case in the analysis will not change the main results in this papaer. It only requires more conditions.

Case 6. $(NL, L\text{-}NL)$: The price for unlabelled non-GMF must be the same as that for (unlabelled) GMF. The dominant firm chooses the price with taking the supply of the unlabelled and labelled non-GMF into account. As discussed in the previous case, if the price of unlabelled products is less than c_1, the fringe supply of unlabelled non-GMF is zero. The products that are actually produced and consumed are only unlabelled GMF and labelled non-GMF. The equilibrium outcome in this case is hence the same as that in case 4, except for the existence of the supply of unlabelled non-GMF with zero demand.

3.2 Stage 2

I now examine the second stage. I first look at the subgame that follows the home government's decision of not imposing mandatory labelling of GMF. In this case, both the dominant firm and the fringe firms are free to choose either voluntary labelling or no labelling. It is then shown that the dominant firm never chooses to provide voluntary labelling. Given GMF being unlabelled, it cannot be a Nash equilibrium (NE) that all fringe firms do not label their products. This is because a single fringe firm can earn positive profits by deviating from no labelling to voluntary labelling, given all other fringe firms providing unlabelled non-GMF. Since labelled non-GMF is distinguished from the other products and since consumers have higher willingness to pay for non-GMF, labelled non-GMF can be sold at a higher price than that of unlabelled products. It *is*, on the other hand, an NE that all fringe firms voluntarily label their products. No fringe firm can be strictly better off by deviating from labelling to no labelling. Providing unlabelled non-GMF ends up with no production. Otherwise, the fringe firm that provides unlabelled non-GMF only earns negative profits because the price of unlabelled products is less than c_1. It is also an NE that some fringe firms choose no labelling, while the other fringe firms choose voluntary labelling. The fringe firms that provide unlabelled non-GMF only produce zero units and earn zero profits in equilibrium. I thus have:

Lemma 1 *In the subgame where mandatory labelling of GMF is not imposed, the dominant firm never labels its product. In one NE, all fringe firms voluntarily label their products. In another NE, some fringe firms do not label their products, while the other fringe firms do. In any case, information on which product is GMF is completely disclosed.*

(Proofs of lemmas and propositions are presented in the Appendix.)

This lemma implies that even though the home government did not impose mandatory labelling of GMF, the asymmetric information problem could be completely solved as long as voluntary labelling is fully credible.

I now turn to the subgame that follows the home government's decision of imposing mandatory labelling. When the home government imposes mandatory labelling of GMF, the dominant firm has to label its product. The fringe firms, on the other hand, are free to choose either voluntary labelling of non-GMF or no labelling. Consumers know that unlabelled products are all non-GMF. Thus, if one wants to consume non-GMF, she never chooses labelled non-GMF at a higher price as long as unlabelled non-GMF is available. This implies that it cannot be an NE that all fringe firms label their products, because one fringe firm can earn positive profits by deviating from voluntary labelling to no labelling, given all other fringe firms choosing labelling. It *is*, on the other hand, an NE that all fringe firms chooses no labelling for their products, because no firm can be better off by deviation. Some fringe firms may choose voluntary labelling in equilibrium, while demand for labelled non-GMF is zero. Fringe firms earn zero profits in equilibrium anyway. I thus obtain the following lemma:

Lemma 2 *In the subgame where mandatory labelling of GMF is imposed, the dominant firm always labels GMF. In one NE, no fringe firm labels non-GMF. In another NE, some fringe firms voluntarily labels their products, while the other fringe firms do not. In any case, information on which product is GMF is completely disclosed.*

4 Strategic Mandatory Labelling of GMF

The analysis in the previous section has shown that the government intervention is not necessarily required to protect domestic consumers from unintended consumption of lower quality GMF. Based on this result, I explore whether the home government actually has an incentive to impose mandatory labelling of GMF in stage 1.

4.1 Stage 1: Strategic use of mandatory labelling

As shown in the previous section, mandatory labelling of GMF forces the dominant firm to provide labelled GMF. Under mandatory labelling, home consumers consume labelled

GMF and unlabelled non-GMF. When the home government does not impose mandatory labelling of GMF, on the other hand, home consumers consume unlabelled GMF and labelled non-GMF. The home government then imposes mandatory labelling of GMF if home welfare is higher under mandatory labelling. The following proposition is obtained.

Proposition 1 *In SPNE the home government imposes mandatory labelling of GMF if and only if* $2\{4q(1-q)\bar{\theta} - (5-3q)qc_1 + (1+q)c_2\} + (1-3q)(1-q)s > 0$.

The main factors in deciding whether mandatory labelling is imposed are labelling cost and the dominant firm's rents. Under voluntary labelling, labelling cost is entirely paid by home consumers who consume non-GMF. Moreover, the dominant firm extracts extra rents under voluntary labelling by increasing the price of GMF in response to an increase in the price of non-GMF. Under mandatory labelling, by contrast, part of labelling cost is paid by the dominant firm, while the rest of labelling cost is paid by home consumers who consume GMF. Home welfare is then higher under mandatory labelling than under voluntary labelling if the sum of the total labelling cost and the extra rents extracted by the dominant firm under voluntary labelling is higher than the labelling cost paid by the home country under mandatory labelling. The inequality in Proposition 1 corresponds to $x_1^p > (1-q)x_2^p/2 - (1-3q)s/8q$, where x_1^p and x_2^p are given by Eqs. (4) and (3). This inequality implies that home welfare is higher under mandatory labelling if demand for non-GMF is sufficiently large compared to that for GMF. When demand for non-GMF is sufficiently large, total labelling cost under voluntary labelling is sufficiently large. In that case, shifting part of labelling cost to the dominant firm makes the home country better off. Mandatory labelling is thus imposed.[21]

The foreign dominant firm's profits are lower under mandatory labelling than under voluntary labelling, i.e., $\pi_2^m < \pi_2^v$. This means that mandatory labelling improves home welfare at the expense of the foreign country.[22]

[21] Since the strategic use of mandatory labelling is motivated by cost-shifting effect, mandatory labelling may be imposed even in the case where total labelling costs are lower under voluntary labelling.

[22] It is important to note that the presence of credible voluntary labelling plays an important role. In order for the cost-shifting effect to be a gain under mandatory labelling, the home economy must pay labelling cost in the absence of mandatory labelling.

4.2 Is mandatory labelling protectionist?

It is too early to conclude that mandatory labelling imposed for strategic purpose is protectionist. The home government may also impose mandatory labelling of GMF even in a *hypothetical integrated economy* where all firms were domestic. If so, it is not considered to be protectionist because the behaviour of the government is not distorted by the fact that those who are hurt by the policy are located in the foreign country. Here, I define protectionism in the following way:

Definition 1 *Mandatory labelling is said to be protectionist if the government imposes it in the original trading economy, while it would not impose it in a hypothetical integrated economy where all firms were domestic.*

This definition of protectionist labelling is similar to that of protectionist standards by Fischer and Serra (2000).[23] Definition 1 implies that mandatory labelling is judged to be protectionist if welfare gain in the home country by imposing mandatory labelling is smaller than welfare loss in the foreign country.

Consider the hypothetical integrated economy where all firms are domestic. The dominant firm's profits are included as part of home welfare. Home welfare in the hypothetical integrated economy is thus given by $W_I = CS + \pi_2$. The home government imposes mandatory labelling in the hypothetical economy if and only if $W_I^m = CS^m + \pi_2^m > W_I^v = CS^v + \pi_2^v$, or $CS^m - CS^v > \pi_2^v - \pi_2^m$, where CS^v, CS^m, π_2^v, and π_2^m are given by Eqs. (12), (9), (11), and (8), respectively. If $0 < CS^m - CS^v < \pi_2^v - \pi_2^m$, on the other hand, the home government *does* impose mandatory labelling in the original trading economy but does *not* in the hypothetical integrated economy. This is the case of protectionist labelling. The condition for mandatory labelling being protectionist is as follows:

Proposition 2 *Mandatory labelling imposed by the home government is protectionist if* $2\{4q(1-q)\bar{\theta} - (7-q)qc_1 + 3(1+q)c_2\} + (1-q)(3-q)s < 0$.

The inequality in Proposition 2 corresponds to $x_1^p < (3+q)x_2^p/2 - (3-q)s/8q$, where x_1^p and x_2^p are given by Eqs. (4) and (3). This condition means that mandatory labelling is protectionist if demand for non-GMF is sufficiently high but not too high, compared

[23] They define a minimum quality standard to be protectionist if it differs from what the government would set in a hypothetical integrated economy.

to that for GMF. As is shown in Proposition 1, mandatory labelling is imposed when demand for non-GMF is sufficiently high. If demand for non-GMF is so high, welfare gain in the home country is larger than welfare loss in the foreign country and hence mandatory labelling is not protectionist. If demand for non-GMF is not too high, on the other hand, welfare gain from mandatory labelling is smaller than the loss in the dominant firm's profits. Since the home government does not take into account the dominant firm's profits in the trading economy, it imposes mandatory labelling even in such a case.

In the hypothetical integrated economy, shifting part of labelling cost to the dominant firm is not a real gain. Labelling cost is paid within the economy anyway. In the trading economy, by contrast, it *is* a real gain. The home country can be better off by shifting part of labelling cost to the dominant firm.

5 Extensions of the Model

In this section, I briefly discuss some extensions of the model and examine how robust the main claims in the previous sections are under various assumptions.

5.1 Upward sloping fringe supply

The analysis can be extended to the case where the fringe supply is less than perfectly elastic. Let $C_1(x_1)$ be the aggregate production cost of the fringe firms, where $C_1'(\cdot) > 0$ and $C_1''(\cdot) > 0$. The fringe supply is then given by $p_1 = C_1'(x_1)$. The production cost of the dominant firm can also be generalized. Let $C_2(x_2)$ be the production cost of the dominant firm, where $C_2'(\cdot) > 0$ and $C_2''(\cdot) > 0$. Then, it can be shown that the qualitative results in the previous sections are unchanged. The only major change is that there is now positive producer surplus for the fringe, which is higher under mandatory labelling because the fringe output is higher under mandatory labelling. It implies that producer surplus of the domestic fringe under mandatory labelling is higher than or equal to that under voluntary labelling, which gives an *additional strategic motive* for the home government to impose mandatory labelling.

5.2 GMO as an intermediate input

One may find the model in the previous sections too simple and specific. In particular, the vertical structure in the agricultural and food sector was abstracted. In the real world, the innovated GMOs are usually used as intermediate inputs in the food production. Typically, it is observed that the innovating firm does not directly engage in production of the final good, while producers of the final good do not engage in the innovation of GMOs. For example, an innovating firm produces and sells GM seeds to farmers.

Taking this into account, modify the model to make x_1 and x_2 as intermediate inputs. I assume that one unit of a final good z_i is produced from one unit of x_i, $i = 1, 2$. The final good is produced by perfectly competitive "farmers." Let r_i be the price of z_i, $i = 1, 2$. Then, under voluntary labelling, $r_1^v = p_1 + s = c_1 + s$ and $r_2^v = p_2^v$. Under mandatory labelling, $r_1^m = p_1^m = c_1$ and $r_2^m = \tilde{p}_2^m + s$. The only difference from the previous results is the price of x_2 under mandatory labelling, $\tilde{p}_2^m$. In this case, under mandatory labelling the competitive farmers who produce GMF from the GM intermediate input have to label their products. The unit cost of z_2 rather than that of x_2 increases by s. This, however, reduces the derived demand for x_2 and forces the dominant firm to *decrease* p_2. Thus, r_2 increases by less than s under mandatory labelling, which implies labelling cost is partly shifted to the dominant firm, just like the previous case. Basically, the qualitative results in the previous sections are not affected by the introduction of the final good sector.

5.3 Labelling is not fully credible

Labelling may not be fully credible. Suppose first that *voluntary labelling is not fully credible.*[24] Then, voluntary labelling cannot completely solve the asymmetric information problem. Since mandatory labelling has higher informational value in this case, consumer protection can be a motive to impose mandatory labelling. However, the strategic incentive to impose mandatory labelling still exists unless voluntary labelling has no credibility.[25] Mandatory labelling may also be protectionist.

[24] This may be because food is a credence good and there are a large number of firms that sell non-GMF. For example, Rege (2000) argues that while independent third parties can sell credible signals, signals by individual firms are hardly credible when there are a large number of firms in an industry.

[25] If voluntary labelling has no credibility, cost-shifting effect disappears because no firm provides voluntary labelling and the home country does not pay labelling costs without mandatory labelling.

Suppose next that *mandatory labelling is not fully credible*.[26] Then, under mandatory labelling some of the GMF may be provided without labelling. Non-GMF producers may have to pay costs to separate their products from GMF.[27] Thus, labelling costs may be partly required for the non-GMF market even under mandatory labelling, which makes cost-shifting effect of mandatory labelling smaller. Mandatory labelling is thus less likely to be imposed for strategic purpose, as it is less credible.[28]

6 Conclusions

The recent dispute on mandatory labelling of biotechnology products has raised the issue of possible use of mandatory labelling as protectionism. Importing countries argue that mandatory labelling is necessary for protecting consumers from unintended consumption of lower quality biotechnology products. Exporting countries, on the other hand, argue that importing countries impose mandatory labelling from protectionism rather than for consumer protection. This paper has examined this issue from a theoretical point of view.

This paper has shown that the government of the importing country may actually have incentives to impose mandatory labelling of biotechnology products for reasons other than consumer protection. When consumers perceive biotechnology products as being of lower quality, firms that produce conventional products voluntarily label their products. Thus, as long as voluntary labelling is fully credible, information on the process attribute of a product is fully disclosed without government intervention. Nevertheless, the importing country may impose mandatory labelling because it can shift part of labelling cost to the foreign producer of biotechnology products by doing so. The foreign producer would also earn extra rents under voluntary labelling. As a result, although voluntary labelling provides the same information as mandatory labelling does, the importing country may be better off under mandatory labelling. The strategic use of mandatory labelling, however, is not considered to be protectionist unless welfare gain in the importing country from imposing mandatory labelling is smaller than welfare loss in the exporting country.

Policy implications of the paper are as follows: For exporting countries of biotechnology products, this paper suggests that importing countries may actually impose manda-

[26] This may be because the enforcement by the government is not perfect.

[27] For example, they may have to make sure that GMF are not mixed with non-GMF in the distribution process.

[28] A similar result will be derived if the enforcement cost of mandatory labelling is not negligible.

tory labelling of those products for strategic purpose. Thus, exporting countries should carefully examine the importing county's motives to impose mandatory labelling. For importing countries, on the other hand, if they impose mandatory labelling of biotechnology products for consumer protection, they should show that welfare gain from mandatory labelling is greater than welfare loss. By doing so, they could respond to the criticism of mandatory labelling being protectionism.

A Appendix: Proofs of Propositions and Lemmas

A.1 Proof of Lemma 1

I first show that the dominant firm never chooses to provide voluntary labelling. Suppose that all fringe firms provide voluntary labelling. Then, if the dominant firm does not label its product, it earns $\pi_2^v = (q(c_1 + s) - c_2)^2/4q(1-q)$ (Eq. (11)). If it labels its product, on the other hand, it earns $\pi_2^{LL} = (qc_1 - c_2 - (1-q)s)^2/4q(1-q)$ (Eq. (7)). It is easily shown that $\pi_2^v > \pi_2^{LL}$. No labelling is hence the best response for the dominant firm. Suppose next that some fringe firms do not label their products, while the other fringe firms provide voluntary labelling. If the dominant firm does not label its product, its profits are again given by π_2^v. If it labels its product, on the other hand, its profits are given by $\pi_2^m = (qc_1 - c_2 - s)^2/4q(1-q)$ (Eq. (8)). Since $\pi_2^v > \pi_2^m$, then no labelling is the best response for the dominant firm. Suppose finally that no fringe firm provides voluntary labelling. In this case, if the dominant firm does not label its product, its profits are given by $\pi_2^M = (q\bar{\theta} - c_2)^2/4q$ (Eq. (13)). If it labels its product, on the other hand, its profits are again given by π_2^m. The conditions for positive demands for both products presented in footnote 18 require that q is in the range of $(c_2+s)/c_1 < q < (2\bar{\theta} - 2c_1 + c_2 - 2s)/(2\bar{\theta} - c_1 - s)$. Moreover, the condition for the dominant firm being able to charge the monopoly price requires that $q < (2c_1 - c_2)/\bar{\theta}$. When q satisfies these conditions, it is shown that $\pi_2^M > \pi_2^m$ holds. Thus, no labelling is again the best response for the dominant firm.

Given the dominant firm providing unlabelled GMF, I next show that it is *not* an NE that no fringe firm labels its product. Consider that a single fringe firm deviates from no labelling to voluntary labelling. Since this firm is the only firm that provides labelled non-GMF, it can charge a price $p_1 > c_1 + s$ and earn positive profits by the deviation.

It *is* an NE that all fringe firms provide voluntary labelling. Consider that a single fringe firm deviates from labelling to no labelling. Since GMF is also unlabelled, the same price must be given to GMF and unlabelled non-GMF. The dominant firm chooses the price of unlabelled product below c_1 and hence the deviated fringe firm can only earn negative profits if it produces a positive unit. At best the deviated firm earns zero profits by producing zero units.

Finally I show that it is also an NE that some fringe firms provide voluntary labelling, while the other fringe firms do not label their products, as long as a sufficiently large number of fringe firms choose voluntary labelling. As is discussed above, the fringe firms that do not label their products produce nothing in order to avoid negative profits. The firms that choose voluntary labelling also earn zero profits as long as a sufficiently large number of fringe firms choose voluntary labelling. Then, neither unlabelled non-GMF producers nor labelled non-GMF producers have an incentive to deviate.

The equilibrium outcome in this subgame corresponds to that of case 4 in section 3.1. Since unlabelled GMF and labelled non-GMF are only produced and consumed in the market, information on which product is GMF is completely disclosed. *Q.E.D.*

A.2 Proof of Lemma 2

Mandatory labelling of GMF forces the dominant firm to label its GMF. Consumers know that unlabelled products are all non-GMF. If both labelled and unlabelled non-GMF are supplied in the market, those who want to consume non-GMF choose the cheaper one.

I first show that it is *not* an NE that all fringe firms label their products. Consider that a single fringe firm deviates from labelling to no labelling. This deviated firm is the only firm that provides unlabelled non-GMF and hence can charge a price $p_1 \in (c_1, c_1 + s)$ and earn positive profits.

I next show that it *is* an NE that all fringe firms provide unlabelled non-GMF. Consider that a single fringe firm deviates from no labelling to labelling. By providing voluntary labelling, this deviated firm's unit cost is $c_1 + s$ and hence it cannot charge a price less than $c_1 + s$. Since consumers know that unlabelled products at price c_1 are all non-GMF, no one buys labelled non-GMF at a higher price. Profits of the deviated fringe firm are hence zero, which are the same as those in the case of no deviation.

I finally show that it is also an NE that some fringe firms provide labelled non-GMF and the other fringe firms provide unlabelled non-GMF. As is discussed above, demand for labelled non-GMF is zero as long as unlabelled non-GMF is supplied in the market. The firms that provide unlabelled non-GMF also earn zero profits as long as a sufficiently large number of fringe firms provide that product. In this situation, neither unlabelled non-GMF producers nor labelled non-GMF producers have an incentive to deviate because they earn zero profits anyway.

The equilibrium outcome in this subgame corresponds to that of case 2 in section 3.1. Since labelled GMF and unlabelled non-GMF are only produced and consumed in the market, information on which product is GMF is completely disclosed. *Q.E.D.*

A.3 Proof of Proposition 1

By Lemma 1, without mandatory labelling of GMF home welfare is given by CS^v (Eq. (12)). By Lemma 2, with mandatory labelling of GMF home welfare is given by CS^m (Eq. (9)). It then yields that $CS^m - CS^v = (s/2)\{2x_1^p - (1-q)x_2^p + (1-3q)s/4q\}$. Thus, $CS^m - CS^v > 0$ holds if and only if

$$x_1^p > (1-q)x_2^p/2 - (1-3q)s/8q. \tag{A.1}$$

There are three cases to consider: (i) $q \in (0, 1/3)$, (ii) $q = 1/3$, and (iii) $q \in (1/3, 1)$. First, when $q \in (0, 1/3)$, (A.1) holds if and only if $s > -2\left\{4q(1-q)\bar{\theta} - (5-3q)qc_1 + (1+q)c_2\right\}/\{(1-3q)(1-q)\}$. If $4q(1-q)\bar{\theta} - (5-3q)qc_1 + (1+q)c_2 \geq 0$, or $x_1^p \geq (1-q)x_2^p/2$, holds, then this inequality always holds. Second, when $q = 1/3$, (A.1) holds if and only if $4q(1-q)\bar{\theta} - (5-3q)qc_1 + (1+q)c_2 > 0$. Third, when $q \in (1/3, 1)$, (A.1) holds if and only if $s < 2\left\{4q(1-q)\bar{\theta} - (5-3q)qc_1 + (1+q)c_2\right\}/\{(3q-1)(1-q)\}$. The existence of s that meets this inequality requires $4q(1-q)\bar{\theta} - (5-3q)qc_1 + (1+q)c_2 > 0$. *Q.E.D.*

A.4 Proof of Proposition 2

Use Eqs. (11), (12), (8), and (9) to yield $\pi_2^v - \pi_2^m - (CS^m - CS^v) = (s/2)\{(3+q)x_2^p - 2x_1^p - (3-q)s/4q\}$. Thus, $\pi_2^v - \pi_2^m > CS^m - CS^v$ holds if $x_1^p <$

$(3+q)x_2^p/2-(3-q)s/8q$. This inequality holds if and only if

$$s < \frac{2\{(7-q)qc_1 - 3(1+q)c_2 - 4q(1-q)\bar{\theta}\}}{(1-q)(3-q)}. \tag{A.2}$$

In order for the right hand side of (A.2) to be positive it must be satisfied that $4q(1-q)\bar{\theta}-(7-q)qc_1+3(1+q)c_2<0$, or $2x_1^p<(3+q)x_2^p$. Since $4q(1-q)\bar{\theta}-(7-q)qc_1+3(1+q)c_2<4q(1-q)\bar{\theta}-(5-3q)qc_1+(1+q)c_2$, it is possible to have $4q(1-q)\bar{\theta}-(5-3q)qc_1+(1+q)c_2>0$ and $4q(1-q)\bar{\theta}-(7-q)qc_1+3(1+q)c_2<0$ at the same time. *Q.E.D.*

References

[1] Bagwell, K. and R. W. Staiger (1989), 'The role of export subsidies when product quality is unknown.' *Journal of International Economics* 27: 69-89.

[2] Bond, E. W. (1984), 'International trade with uncertain product quality.' *Southern Economic Journal* 51: 196-207.

[3] Bureau, J.-C., S. Marette, and A. Schiavina (1998), 'Non-tariff trade barriers and consumers' information: The case of the EU-US trade dispute over beef.' *European Review of Agricultural Economics* 25: 437-462.

[4] Chataway, J. and G. Assouline (1998), 'Risk perception, regulation and the management of agro-biotechnologies,' in J. Senker, ed., *Biotechnology and Competitive Advantage: Europe's Firms and US Challenge*. Cheltenham: Edward Elgar.

[5] Commission of the European Communities, Directorate-General for Agriculture (2000), 'Economic impacts of genetically modified crops on the agri-food sector: A first review.' Working Document. Available at http://europa.eu.int/comm/agriculture/publi/index.en.htm

[6] Darby, M.R. and E. Karni (1973), 'Free competition and the optimal amount of fraud.' *Journal of Law and Economics* 16: 67-88.

[7] Donnenfeld, S., S. Weber, and U. Ben-Zion (1985), 'Import controls under imperfect information.' *Journal of International Economics* 19: 341-354.

[8] Emons, W. (1997), 'Credence goods and fraudulent experts.' *Rand Journal of Economics* 28(1): 107-119.

[9] Emons, W. (2001), 'Credence goods monopolists.' *International Journal of Industrial Organization* 19(3-4): 375-389.

[10] Feddersen, T.J. and T.W. Gilligan (2001), 'Saints and markets: Activists and the supply of credence goods.' *Journal of Economics and Management Strategy* 10(1): 149-171.

[11] Fischer, R. and P. Serra (2000), 'Standards and protection.' *Journal of International Economics* 52: 377-400.

[12] Gaisford, J.D. and C. Lau (2000), 'The case for and against import embargoes on products of biotechnology.' *The Estey Centre Journal of International Law and Trade Policy* 1: 83-98. URL: http://www.esteyjournal.com

[13] Grossman, G.M. and H. Horn (1988), 'Infant-industry protection reconsidered: The case of informational barriers to entry.' *Quarterly Journal of Economics* 103: 767-787.

[14] Kerr, W.A. (1999), 'International trade in transgenic food products: A new focus for agricultural trade disputes.' *World Economy* 22: 245-259.

[15] KPMG Consulting (2000), 'Economic study: Potential costs of mandatory labelling of food products derived from biotechnology in Canada.' Project report. Ottawa.

[16] James, C. (2001), 'Preview: Global review of commercialized transgenic crops: 2001.' International Service for the Acquisition of Agri-biotech Applications (ISAAA). Available at http://www.isaaa.org.

[17] Lapan, H. and G. Moschini (2000), 'Incomplete adoption of a superior innovation.' *Economica* 67: 525-542.

[18] Marette, S., J.-C. Bureau, and E. Gozlan (2000), 'Product safety provision and consumers' information.' *Australian Economic Papers* 39(4): 426-441.

[19] Moschini, G. and H. Lapan (1997), 'Intellectual property rights and the welfare effects of agricultural R&D.' *American Journal of Agricultural Economics* 79: 1229-1242.

[20] Nelson, P. (1970), 'Information and consumer behavior.' *Journal of Political Economy* 78: 311-329.

[21] Pitchik, C. and A. Schotter (1987), 'Honesty in a model of strategic information transmission.' *American Economic Review* 77(5): 1032-1036.

[22] Plunkett, M.D. and J.D. Gaisford (2000), 'Limiting biotechnology?: Information problems and policy responses.' *Current Agriculture, Food, and Resource Issues* 1: 21-28. URL: http://www.cafri.org

[23] Raff, H. and Y. Kim (1999), 'Optimal export policy in the presence of informational barriers to entry and imperfect competition.' *Journal of International Economics* 49: 99-123.

[24] Rege, M. (2000), 'Strategic policy and environmental quality.' *Environmental and Resource Economics* 15: 279-296.

[25] Taylor, C.R. (1995), 'The economics of breakdowns, chekups, and cures.' *Journal of Political Economy* 103(1): 53-74.

[26] USDA National Agricultural Statistics Service (NASS) (2000), *Acreage Report 2000.* Available at http://www.usda.gov/nass/

[27] USDA National Agricultural Statistics Service (NASS) (2002), *Acreage Report 2002.* Available at http://www.usda.gov/nass/

[28] Wolinsky, A. (1993), 'Competition in a market for informed experts' services.' *Rand Journal of Economics* 24(3): 380-398.

[29] Wolinsky, A. (1995), 'Competition in markets for credence goods.' *Journal of Institutional and Theoretical Economics* 151(1): 117-131.