Labeling of Genetically Modified Organisms and the Producer's Negative Labeling Decision under a Voluntary Labeling Regime

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Abstract

During the past decade, there has been growing public attention and concern over consuming products containing or processed with genetically modified organisms (GMOs). Labeling of the food products derived from the use of GMOs has thereby been a contentious debate across the world. Currently, there are two systems with regard to labeling GMO-based products: mandatory versus voluntary. The purpose of this study was to survey the research on GMOs, its application in agriculture and the surrounding labeling issues. A theoretical model was developed to analyze non-GMO producers' labeling decisions under a voluntary labeling regime, aimed at providing a theoretical perspective for governments that are contemplating the adoption of a voluntary approach to regulate GMO food products. The analysis indicates that the size of labeling costs and consumers' preferences toward non-GMO products are critical factors that will impact on non-GMO producers' labeling decisions.

Résumé

Durant la dernière décennie, les produits génétiquement modifiés (GMOs) ont attiré l'attention du public et du même fait causé une inquiétude grandissante. L'étiquetage des produits alimentaires dérivés de l'usage des produits GMO est donc devenu un sujet de débat contesté à travers le monde. Actuellement, il existe deux systèmes d'étiquetage des produits GMO: obligatoire et volontaire. Le but de cette étude était de survoler la littérature existante sur les organismes GMO, ces applications à l'agriculture et les problèmes associés aux questions d'étiquetage. Un modèle théorique fut développé afin d'analyser les décisions des producteurs d'aliments non-GMO d'étiqueter leurs produits sous un régime d'étiquetage volontaire. Les résultats du modèle serviront à informer et guider les gouvernements qui considèrent adopter une approche volontaire pour gérer les aliments provenant de produits GMO. L'analyse présentée dans cette étude indique que les coûts d'étiquetage ainsi que les préférences des consommateurs envers les produits non-GMO sont les facteurs qui importent le plus sur la décision des producteurs de produits non-GMO d'étiqueter ou non leurs produits.

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Chapter 1: Introduction

1.1 Overview

Over the past several years a great amount of public attention and concern have been drawn to the controversy over products containing or processed with genetically engineered/modified organisms (GMOs). The subject of GMOs has provoked extensive and intense debate that has centered primarily on two areas: GMO food and environmental safety assessment and information disclosure through labeling. Much of the public is concerned about possible risks associated with GMOs. Although most countries have effective systems to protect consumers from exposure to food contamination, risk or damage, the increasing controversy over the safety of GMOs with regard to human health and/or the environment has raised the prospect of labeling all products containing GMOs (Miller, 1999; Stilwell and Dyke, 1999). The most contentious issues regarding GMO labeling include whether labeling should be required on all GMOs; and, if a product containing or processed with GMOs should be labeled, should the labeling be mandatory or voluntary, and how should GMOs be labeled.

Two opposite camps have emerged in the heated debate over labeling GMOs. The EU-led camp believes that GMO food must be labeled because labeling gives consumers a choice whether to purchase the product in question or to choose a substitute. The US-led camp does not require GMOs to be labeled unless the GMO food is found to be significantly different from conventional food, or that the GMO food poses risks to public health. Currently, consensus has not yet been reached internationally on whether GMO labeling should be mandatory or voluntary.

GMO products entered the marketplace in the early 1990s and the biotechnology was adopted so quickly that by 1999 more than 40 genetic modifications related to 13 different crops had been approved and produced in 12 countries, as well as distributed among other countries through international trade (Phillips and Isaac, 1998; Phillips and McNeill, 2000). The distinctive feature of GMOs is that they involve the transfer of genetic material between organisms in a manner different from traditional breeding (Fulton *et al*, 2001). The dominant applications of biotechnology in agriculture have aimed to create pest and herbicide-resistant traits to reduce production inputs and increase yields (Miller, 1999), however there are other innovations that seek to provide positive end-use characteristics.

Since the late 1990s, however, consumers in some countries have shown growing and widespread concern regarding the safety of GMOs (Phillips and McNeill, 2000). Consumers are especially concerned about the long-term effects on their health and the environment from consuming GMO-based products (Miller, 2002). Consumers in the European Union have shown the strongest concern, and this concern has since then spread worldwide (Lence and Hayes, 2004). Given these concerns consumer groups and environmental activists have called for a ban on GMOs in food products, or have demanded mandatory labeling to regulate the distribution and trade of GMO-based products (Greenpeace, 1997; Friends of the Earth, 2001; Consumer Report, 1999); On the other end of the debate are food production industry, seed technology innovators, farmers and processors, who argue that a stringent labeling policy on the use of GMOs would disrupt of the marketing of products and eventually impede the development of new technology in agriculture (Kirchhoff and Zago, 2001; Runge and Jackson, 2000).

Among the many benefits of labeling GMOs, the one most often mentioned is to satisfy the consumers' right to know. Labeling can help consumers choose products according to their ethical, religious, cultural, and dietary and risk preferences (Bhatia and Powell, 2000; Stilwell and Dyke, 1999). But labeling adds costs as well. In addition to the costs of physical labeling, segregation, identity preservation, monitoring and testing are significant costs that both regulators and producers must consider. At the industry level, a producer's labeling decision is determined by weighing the associated benefits and costs, especially under a voluntary labeling scheme. Under a mandatory labeling scheme, producers are forced to comply with the labeling requirement, and governments use monitoring and fines to ensure compliance with and credibility of labeling.

Under a voluntary labeling scheme, the labeling decision is left completely to producers. It is unlikely that GMO producers would voluntarily label the presence of GMOs due to consumers' current resistance to GMOs. Therefore, the labeling decision only involves non-GMO producers. In the future, GMO producers may wish to label in order to indicate some positive attributes of their products. Whether non-GMO producers label their products or not depends on whether labeling gives them more market share without reducing their unit margin, or improves their unit profitability without costing them market share. Previous analysis has found that consumers' valuation of non-GMO products, and the size of segregation and identity preservation costs, are crucial factors that contribute to non-GMO producers' labeling decision (Giannakas and Fulton, 2002). In addition, GMO producers' marketing strategy could greatly impact non-GMO producers' labeling decision as well. When GMO and non-GMO products coexist in the market, if GMO producers use the production cost savings from the adoption of GMO technology to lower the market price, then non-GMO producers' market share will be affected.

1.2 Problem Statement

In 1997 the EU passed a law to enact a mandatory labeling policy among its member countries to regulate the trade and distribution of GMO-based products (Bhatia and Powell, 2000); and on September 1, 1998 the labeling policy took effect for GMO-based soybeans and corn. Other countries such as Japan, South Korea, Australia and New Zealand then followed by implementing similar policies. In contrast, the United States implemented a voluntary labeling policy that allows producers to release information about the presence or absence of GMOs in their products on a voluntary basis. Canada and Argentina use a labeling policy similar to the US. It is likely that divergent labeling policies in the main producing and consuming countries will impact both international trade and the future development of GMO-based products. Therefore an initiative has arisen to establish an agreed Codex standard in terms of GMO labeling, to facilitate international trade (Codex, 1993).

1.3 Objectives

The objective of this thesis is two fold. The first objective is to survey the research on GMOs and the surrounding labeling issues. This includes the background of GMOs' development in the commercial world, the rise of the GMO labeling debate, and contentious issues regarding GMO labeling. Consumers' attitudes and behaviours also will be examined. Several areas will be discussed in an attempt to shed light on consumers' perceptions of genetically modified foods:

- Introduction of biotechnological development
- Critical events related to biotechnology in recent years
- Comparison of consumers' perceptions of biotechnology in different countries

The second objective is to theoretically examine producers' labeling decisions, especially under a voluntary labeling regime, as in Canada. Most literature has focused on examining consumers' welfare under alternative labeling regimes, but producers' choices have not been fully covered (Giannakas and Fulton, 2002; Kirchhoff and Zago, 2001). This thesis attempts to explore producers' profits under different labeling policies, and to analyze how those profits are affected by consumption demand and segregation costs.

1.4 Thesis Structure

The structure of this thesis is as follows. Chapter 2 provides research on the creation and development of consumers' demand for GMO labeling. This chapter starts by introducing GMOs' scientific background and application in agriculture. The second part of the chapter examines how consumers' attitudes toward GMOs have evolved over the past decade. The critical food crises that took place in recent years are reviewed to discuss their influence on shaping consumers' views toward biotechnology, insofar as this influences the demand for labeling GMOs. Then the third part of the chapter outlines the two prevailing labeling policies with regard to GMO products - mandatory versus voluntary labeling policies.

Chapter 3 further explores GMO labeling policies in both theory and practice. First, the chapter presents the rationale behind the opposing labeling policies. Then the practical application of labeling policies in the main markets is discussed, and the current practice in Canada is outlined. The last part of the chapter examines the economic implications of the differing labeling policies. Chapter 4 develops a conceptual framework to examine producers' responses to a voluntary labeling policy, and examines producers' negative labeling decisions under a voluntary labeling system from various aspects. The final chapter presents the study's conclusions, discusses some of the study's limitations, and suggests some directions for future research.

Chapter 2: GMOs and Labeling

2.1 GMO Development and Applications

Over the past century, technological innovations have brought major breakthroughs in agriculture. For example, total agricultural output between 1900 and 2000 in the United States increased fivefold, while total inputs stayed roughly the same (Moschini, 2001). Since transgenic crops entered the market in the early 1990s, the worldwide production area for GMO plants has multiplied quickly. According to the ISAAA (2006) status report published in January 2007, the worldwide area planted with genetically modified plants reached 102 million hectares in 2006. The US, followed by Argentina, Brazil, Canada, India and China were the leading GMO crop growers in 2006. India, the largest cotton grower, was reported to have the most significant increase in 2006, with its GMO cotton cultivation nearly tripling to 3.8 million hectares. Brazil enjoyed a 22% increase in soy, amounting to 11.5 million hectares. Argentina ranked second with a total planted area of 18 million hectares. The largest producer of GMO crops still remains the US, with an increase of 4.8 million hectares, to a total of 54.6 million hectares. Among all the GMO varieties, soybeans remain the most common GMO plant, with a production area that increased from 54.6 million hectares in 2005 to 58.6 million hectares in 2006; followed by corn, which increased from 21.2 to 25.2 million hectares; and cotton, from 9.8 to 13.4 million hectares. It is noteworthy that in 2006, a new biotech crop, herbicide tolerant alfalfa, was commercialized for the first time in the US. GMO plants were developed starting with useful characteristics such as herbicide tolerance and insect and virus resistance. Herbicide tolerance (HT), for example, is a transgenic attribute used to control weeds without destroying the crop, allowing farmers to use more effective herbicides. Pest-resistant crops, on the other hand, contain a trait to make them insect resistant. Bacillus thurigiensis (Bt), for example, is a toxin to common crop pests and has been used to render Bt-cotton resistant to bollworm infestation and Bt-corn resistant to the European Corn Borer (Feldmann *et al*, 2001; Fulton *et al,* 2001; Moschini, 2001). Most GMO crops are either herbicide tolerant or insect resistant, but there are a small growing number of varieties with 'stacked genes' traits – containing both HT and Bt traits, such as GMO cotton and GMO corn (Codex, 2005).

The first genetically modified plants were produced in 1983, and the first genetically modified food entered the market in 1994 (Bergh and Holley, 2001; McHugen, 2000). In 1983, four separate groups of scientists created GMO plants, of which three groups successfully inserted bacterial genes into plants, and one inserted a gene into a sunflower. In 1994 the FlavrSavr tomato was introduced into the market, marking the start of the widespread use of genetically modified crop plants in the USA. In 1995 Bt corn (corn modified with a bacterium gene to give it insect resistance) came onto the market. In 1996 Roundup Ready Soybeans (soybeans resistant to Roundup herbicide) were introduced in the USA. Both crops were applied on substantial acreage in 1997 (McBride & Books, 2000). In the following years, the adoption of GMO crops has dramatically expanded in both North and South America. In the US, for example, according to a official statistics from the National Statistics Service (NASS) of the United States Department of Agriculture (USDA), in 2007, GMO soybean plantings had increased to 91% of total American soybean cultivation, GMO cotton plantings had increased to 87% of total cotton production, GMO maize had the greatest expansion which increased from 61% in 2006 to 73% in 2007 (GMO Compass, 2007). HT soybeans in Argentina comprised 95% of total soybean production in 2002 (Foster, 2003). In addition, HT canola has been one of the most rapidly adopted GMOs in Canada. In 1996 HT canola comprised only 4% of Canada's total canola production, in 1998 it was 44%, and it was 70% in 1999 (Fulton and Keyowski, 1999). According to the Ecological Society of America (ESA, 2005), in 2004 the Prairie Provinces produced 98.7% of Canada's total harvested acreage of canola, almost 80% of which was HT canola.

In Europe, only a limited number of countries have been growing GMO crops so far due to regulatory issues and consumer resistance (Koen *et al.*, 2007). In 2006 the total number of countries planting GMO crops reached six, out of which Spain is the leading country by planting 60,000 hectares, followed by France, Czech Republic, Portugal, Germany and Slovakia. However, the adoption of HT technology in sugar beet sector is very appealing for EU agriculture as this GMO crop is grown in most EU countries (Koen *et al.*, 2007).

2.2 What are GMOs?

Different jurisdictions define GMOs differently. Health Canada defines GMOs as the following: "the term 'genetically modified' is applied only to products that have been genetically engineered; that is, where genetic material (deoxyribonucleic acid or DNA) has been manipulated or where genes from one organism (animal, plant species or microorganism) have been transferred to the genetic material of another." (Health Canada website). By the definition, a GMO product is a product derived from the use of the biotechnology. Producing GMOs involves some form of gene splicing and the transfer of genetic material between organisms (Altieri, 1998; Bergh and Holley, 2001; Fulton *et al*, 2001). More specifically, the gene of a foreign organism can be moved and inserted into another organism, which is different from the traditional breeding method. Biotechnology's application is not specific to agriculture, as it has been used for medical and industrial purposes as well (Bergh and Holley, 2001). The widespread use of GMOs touches people's lives in many respects, so it is almost impossible to avoid eating food that uses GMOs directly or indirectly (Miller, 1999). Today the commercial GMOs traded on the market include GMO corn, soybeans, cotton, canola, and a few minor products such as alfalfa. Other GMO products such as rice, wheat, papaya, fish and pig are still at the research or field-testing stage.

Benefits

Because GMO technology allows genes to be transferred between organisms, desirable traits can be transferred through this biotechnology. For example, the Bt gene can be inserted into plants by the process of genetic engineering to develop insect-resistant crops, and the HT trait has also been successfully inserted into plants to provide resistance to specific herbicides. Thus far, the primary objective of adopting biotechnology has been to make plants resistant to specific herbicides and to increase their insect pest resistance, so as to reduce the use of insecticides, herbicides and other chemicals, which then lowers production costs, improves yields and enhances nutritional or other characteristics (Altieri, 1998; Bergh and Holley, 2001; Kirchhoff and Zago, 2001; Klotz-Ingram *et al*, 1999; Moschini 2001; Tyshenko and Leiss, 2004). In addition to the reduced use of pesticides, another potential environmental benefit has also been argued: in the future, genetically engineered crops may be planted on marginal lands, such as salty, dry or acidic soils, thus making better use of limited natural resources.

In terms of yield, Fernandes-Cornejo and McBride (2000) studied HT soybeans and conventional soybeans and found that the yields gained by using HT soybeans were statistically significant. Koziel *et al* (1993) found that Bt corn increased yields by up to 8% over conventional varieties. Quim and Zilberman (2003) found that Bt technology substantially reduces pest damage and increases yields, especially in many developing countries where small-scale farmers suffer large pest-related yield losses due to technical and economic constraints, as in India for example. However, not all studies have found a yield increase for HT soybeans. Surveys of Argentine farmers found that the yield for HT soybeans is the same as the conventional counterparts, but since the total production cost for HT soybeans was significantly lower, the growers could benefit from the adoption of HT crops (Naseem and Pray, 2003; Qaim and Traxler, 2002). In terms of cost, the adoption of GMO varieties can reduce the use of agricultural chemicals and lower the pesticide costs, resulting in input cost savings. For example, Qaim and Traxler (2002) found that the use of herbicides was significantly reduced through the adoption of GMO soybeans, and the cost of herbicide application on GMO crops was two-thirds that of application on conventional crops. Carlson *et al* (1997) estimated that the introduction of Bt corn varieties saved US $2.8 to US $14.5 per acre, Fernandes-Cornejo and McBride (2000) estimated the cost savings from using HT soybeans to be US $9 to US $11 per acre, and Fulton and Keyowski (1999) estimated the cost savings from HT canola to be C $4 to C $10 per acre. These estimates vary depending on region, farmer heterogeneity, weather conditions and level of insect infestation.

It has been argued that developing countries might also reap benefits from genetically modified foods and crops, which could significantly reduce malnutrition and help poor farmers working marginal lands. In 2004 Golden Rice, a kind of rice that can make betacarotene (a source for our body to make vitamin A), was introduced into the market. This food, produced through biotechnology, could save millions of people from Vitamin A deficiency, and thus produce significant health benefits, especially for the poor in developing countries. Genetically-modified agricultural techniques also have the potential to create virus-resistant, drought-tolerant and nutrient-enhanced crops that could improve food security in Africa, Asia and Latin America. Qaim and Zilberman (2003) used field trials of Bt cotton in India to suggest that GMO crops can have significant yield effects on developing countries, such as in South and Southeast Asia and Sub-Saharan Africa, where pest pressure is high, the soil and climatic conditions are less favorable relative to developed countries, as well as with high population growth. If third world countries can benefit from GMOs and overcome their food shortages, they can focus their resources on developing their economies. Food and crop production will increase and the quality of life in these countries will improve dramatically. The potential for these third world countries to overcome poverty, starvation and even social and political unrest with the help of GMOs is significant.

Risks

Despite the early fast development of GMOs in agriculture in the late 1990s, consumers began to express concern about the use of GMOs for various health, ethical, social, dietary, environmental and personal reasons in 1998 (Hobbs and Plunkett, 1999; Stilwell and Dyke, 1999; Phillips and McNeill, 2000). Opponents of this biotechnology point to its "unnaturalness" and its potential negative impacts on human health and the environment (Bergh and Holley, 2001). Opponents have argued that existing methods of testing GMO foods' safety are not convincing. The GMO technologies are not the same as conventional breeding methods, because implanting a gene specific to bacteria, insects or animals into other types of organisms creates organisms that do not exist naturally. Such technologies could go out of control, resulting in pest resistance, causing unpredictable mutations of organisms and unexpectedly creating new diseases or damaging the environment.

Crops genetically engineered to resist herbicides, such as Roundup Ready soybeans and Liberty Link canola, are subjected to direct doses of the herbicide because they do not die from it, unlike traditional plants. This could mean more chemical residue on the food, although this chemical is less toxic than traditional herbicides. Because GMO technology requires the use of antibiotic resistance markers, the possibility exists that this resistance could transfer to animals and people who eat the GMO foods (Novotny, 2003). Because GMO food products involve transferring genetic material from one organism to a completely different one, it may induce the transformed organism to produce unwanted toxins and allergies (Moschini, 2001). For example, people allergic to peanuts might be endangered by eating a GMO tomato that contains a peanut gene. Besides, many other health concerns also exist because there has been no systematic, scientific investigation of GMO foods' health effects (Greenpeace website, 2000). Transferring genes from one food to another may also transfer allergens that consumers may not expect. For example, Brazil nut genes transferred into soybeans caused reactions in people who are allergic to the nut (McHugen, 2000). Opponents worry about individuals reacting to some genes in GMO foods if these allergenic characteristics are not labeled. Some scientists also warn that GMOs could pose a threat to both human health and the environment (Griffiths, 2000).

Although American and Canadian officials have assured the public that the GMO crops are safe, the fact is that the technology is new and our knowledge of genetic technology remains limited. As a matter of fact, some unexpected incidents have already occurred.

Monarch butterfly

In 1999 Losey et al reported, in a laboratory study, that GMO corn pollen harmed Monarch butterflies, leading to wide media coverage discussing the fear that growing biotech crops harms the environment. It is noteworthy that there has been large controversy surrounding the laboratory findings (Pewagbiotech website).

Starlink corn

Starlink corn, a GMO corn developed as an animal feed, was pulled from the market in 2000 because it contained a GMO-derived protein that some feared could cause an allergic reaction in some people.

These incidents undoubtedly raised consumers' concern about consuming GMO related products. Some other incidents have also worsened consumers' concerns. In 1996 the UK experienced a BSE (Bovine Spongiform Encephalopathy) food crisis, which is the widely known "mad cow disease" that could cause a fatal human brain disease. Although BSE had no connection to biotechnology, it helped to focus consumers' attention on food safety issues.

Another problem raised with GMO technologies is that they are currently monopolized by a handful of multinational biotech companies based in developed countries, such as Monsanto in the US (Saito, 1999). Therefore, consumers are suspicious that governments have not been entirely forthcoming about biotech safety, and are concerned with the cozy relationship that appears to exist between government regulators and the biotech industry (Stewart, 2001). In this case, the creation of the biotechnology is considered not to benefit the poor, especially in the developing countries.

Consumers' Attitudes

Consumers' attitudes toward GMOs changed from initially backing the new biotechnology's introduction to suspicion and resistance, along with growing concerns. Surveys have shown that consumers' attitudes toward GMO-based products have been largely negative in recent years. The International Food Information Center (IFIC) has conducted some surveys regarding US consumers' attitudes toward food biotechnology, the first in March 1997, and the most recent in March 2005 (Smith, 2006). The EU has also conducted extensive surveys on biotechnology and food, such as the Eurobarometer surveys, the first of which was done in 1991, and the latest report was just published in February 2006 (Smith, 2006). In Europe, from the beginning of the commercialization of biotech seeds, consumers have expressed intense health and environmental concerns about foods containing GMOs (Zechendorf, 1998; Gaskell *et al*, 1999). In addition, surveys indicate that consumers lack confidence in the regulatory system that is responsible for ensuring food safety due to a series of food scares such as "mad cow" and "foot and mouth" diseases.

Those surveys were conducted mainly in developed countries, such as those in the EU and North America, and in Japan. Some studies, however, have obtained different results in developing countries. Curtis *et al* (2004) conducted a study to examine consumers' attitudes toward GMOs in developing countries and found that, generally, consumers in those countries have a positive perception of GMO products, for many reasons. One major reason is that people in developing countries have more unmet needs than those in developed countries for food availability and sufficient nutrition.

Demand for Labeling

Various concerns about GMO crops have raised consumers' resistance to GMO products in many mainly developed, countries, although government authorities such as the US National Research Council and the EPA claim that no evidence has suggested that foods containing GMOs are not safe to consume. Dr. Val Gidding, vice president for food and agriculture for the Biotechnology Industry Organization (BIO), stated on Oct 16, 2001 that the EPA had completed a nearly two-year scientific review of Bt corn and found that the product posed no risk to human health or to the environment (BIO website, 2001). Nevertheless, consumers' increasing concern over the potential safety issues with using GMOs raises the question of whether all GMO products should be labeled.

Surveys of the demand for GMO labeling

Surveys show that consumers across different countries have generally expressed support for labeling, though to differing degrees. The OECD conducted a survey (1999) in key markets and found that, generally, over 90% of consumers surveyed in the U.S., Canada, the UK, the EU, Australia and New Zealand supported labeling GMO foods. Depending on the specific questions they were asked, 45-93% of consumers surveyed across the US support labeling GMO foods. In Canada the percentage was 83-99%, 94% in the UK, 95% in the EU and 91% in Australia and New Zealand (Phillips and McNeill, 2000). A more recent survey covering the period from 2001-2003 (Food Standards Australia New Zealand, 2003) showed that in the US and Canada, 92% and 85%, respectively, of consumers surveyed supported labeling GMO foods. In the UK the percentage was 94%, in the EU it was 95% and in Australia and New Zealand it was 94% and 64%, respectively. These figures suggest that in recent years, consumers' support for labels on GMO food products has been strong and consistent. This is also reflected in the regulatory approaches taken in these countries. As of August 2001, 28 countries plus the European Union had either adopted or announced plans to introduce labels for GMOs (Phillips and McNeill, 2000).

2.3 GMOs and Labeling

In a perfectly functioning market, consumers have full access to information about products, including how they are processed, their end-use attributes and all the immediate and long-term impacts from consuming the product. As a result, consumers can make informed, rational consumption decisions. Standard economic theory suggests that, in the absence of other market imperfections, that is, if all market participants are fully informed about the product's attributes, then governmental regulation is not required. In the real world, however, the reality is that the market is not perfect.

Asymmetrical Information

A significant imperfection exists when information is asymmetrical, that is, when producers are better informed than consumers about a product's attributes (Caswell and Mojduszka, 1996). When information gaps exist between producers and consumers, consumers may consume products with undesired attributes or pay a price that does not reflect their preferences and risk perceptions associated with the product. Many products include characteristics that consumers cannot fully discern upon purchase, such as the processing method, inputs, nutritional contents, special cooking instructions or ingredients that may cause allergic reactions in some people. Therefore, in these cases consumers cannot make an informed purchase without being provided with the relevant information by the producers who supply the products. In such a situation, governments often intervene in an attempt to correct the imperfect information problem. The government has a number of policy tools with which to intervene, e.g., bans, quotas, educational programs and labeling policies (Golan *et al*, 2001). Under what situations labeling is an appropriate policy tool for resolving information asymmetry is determined by the associated cost-benefit evaluation in relevant situations. Producers rely on their own cost-benefit evaluation to determine what information to supply, while governments and consumers use it to determine what information to require.

Credence Goods and Labeling

In general, goods can be categorized as three types: search goods, experience goods and credence goods (Caswell and Mojduszka, 1996; Darby and Carni, 1973; Segerson, 1999). Search goods are those whose relevant attributes consumers can visually identify upon purchase; for example, color and size. Therefore, consumers can make a rational consumption decision immediately. Experience goods, however, may have attributes that consumers cannot immediately inspect. Through repeated purchases or information gained from other purchasers, however, consumers will finally obtain nearly perfect information about these products, and then make a rational consumption decision. Credence goods are those with attributes that consumers can detect neither upon purchase, nor through repeated purchases, e.g., food safety, nutritional content and the use of GMOs. Consumers can never make rational consumption decisions about credence products without being informed through some other means.

The first two categories of goods require little government intervention because consumers can eventually obtain perfect or near perfect information about the product's attributes. For credence goods, however, governmental intervention can force suppliers to inform consumers about food safety or other risks, or can address market inefficiencies. For example, when public health is at stake, government usually intervenes with regulations to control a product's quality. Government has mandated nutrition labels on all food products, and safe handling labels for fresh meat and poultry (Caswell and Mojduszka, 1996). In some other cases, if government perceives the potential risks or uncertainties as non-lethal, then consumers will be given the option to choose products according to their own preferences. In this case, informational labeling is considered to be a remedy to correct informational asymmetry (Caswell, 2000). An informational labeling policy can help by transforming credence attributes into search attributes so as to mitigate potential market inefficiencies. Consumers can use the label to obtain information and then select products according to their preferences, beliefs or risk perceptions. For example, some consumers would prefer to buy more risky products at lower prices, rather than less risky products at higher prices.

Economics of Labeling

The function of labeling is to help consumers to differentiate the labeled product from otherwise similar products, as well as to identify products' desired attributes that they cannot detect themselves. Labeling is effective as a remedy based on two important conditions. First, an effective label should be a credible and truthful disclosure of the product's information. If the label misrepresents the product it will mislead consumers, so their perceptions about the product's attributes will be incorrect; thus they cannot make the "right" consumption choice. A survey in the EU showed that among 200 items purchased in different regions, nearly one-third were found to contain GMOs when tested, but only one product was so labeled. The other companies denied knowing that their products contained GMOs (Bhatia *et al*, 2000). To ensure compliance with the regulations, the government should use a system of monitoring and fines (Kirchhoff and Zago, 2001), or an entity recognized by consumers should monitor producers' performance. Second, consumers must be informed consumers. Consumers vary in many respects. If a consumer lacks the technical expertise necessary to properly interpret the information on the label, or does not read the label, then labeling is of no value to that consumer. Therefore, how to convey information to consumers in order for them to become fully informed is a crucial issue to be considered by label designers.

On the other hand, labeling imposes costs on the economy. Providing informational labels on products' packages adds a label production cost. Beyond this, effective labeling hinges on four factors: standard setting, testing, certification and enforcement (Golan *et al*, 2001; Zepedal, 2001), all of which have costs. If the labeling program is administered by the government, for example, in the case of a mandatory labeling policy, then the government has to monitor producers to ensure the labels' credibility, and the public will ultimately bear some share of the monitoring and enforcement costs, regardless of whether the government pays those costs or charges fees directly to producers. In the latter case, all the costs due to labeling will be borne by both producers/sellers and consumers because the added labeling costs will be passed through the whole supply chain and reflected in the product's final price.

2.4 Voluntary vs. Mandatory Labeling

In the context of the WTO system, mandatory labels are those that are mandated by regulation and that must be used in order to sell a product in a specific market. The labeling standards and requirements are subject to the WTO's scrutiny. The EU's regulations on the mandatory disclosure of the presence of GMOs was identified as a regulation that could play the role of a "technical barrier to trade" to impede international trade (Phillips and Isaac, 1998). On the other hand, a voluntary labeling policy provides industry with the flexibility to make the labeling decision by itself. Voluntary labels are those that are usually developed by industry through a collaborative process, and the standards and regulations are not necessarily subject to WTO discipline (Chaitoo and Hart, 2000).

Mandatory Labeling

A mandatory labeling policy arises mainly in response to two situations: when consumers cannot obtain sufficient information from the market to make informed and rational consumption decisions, and when individual consumption decisions affect social welfare in a way that the market does not reflect (Golan *et al*, 2001). The first situation occurs when an asymmetric information problem exists between producers and consumers, and the second one occurs when there are externality problems. The reason that the asymmetric information problem might exist is either because the products have negative or undesirable attributes, so that producers do not want to disclose them, or because the products have "public good" attributes, which means labeling the attribute would impose an additional cost on the producer individually, while providing a benefit to the whole industry. For example, the FDA has confirmed that foods containing soy protein may reduce the risk of coronary heart disease, and soya milk is a good source of soy protein. Labeling the benefits of soya milk – a "public good" – will cause the individual producers to incur additional cost, while also benefiting other producers who do not label. In such cases, governments may choose to intervene in the market with a mandatory labeling policy designed to identify certain product attributes to correct the information asymmetry and improve social welfare (Golan *et al*, 2001).

For the sake of public health or safety, the government may impose a mandatory labeling policy. For example, nutritional contents are mandated to be labeled on all food products, and safe handling instructions for fresh meat and poultry are mandatory as well. In these cases, mandatory labeling can enable consumers to choose better nutrition and handle products properly, thereby improving welfare.

Voluntary Labeling

Without governmental intervention, whether consumers can obtain information about credence goods would depend on the producers' voluntary labeling decision. If the labeling decision is left to individual firms, then whether or not they are willing to provide the labels depends crucially on whether they have economic incentives to do so. The incentive for a producer to provide information on products' invisible attributes is that the label can help the producer to sell more products without reducing its price, or to raise the market price without losing sales. Producers determine whether the benefits of labeling outweigh its costs. For example, in markets whose consumers are highly averse to GMO related products, organic producers had been willing to provide organic attribute information on a voluntary basis, although this is now formalized by regulation in many countries.

Under a voluntary labeling system, some factors limit producers' incentive to voluntarily provide informational labeling, because producers do not want to expose a product's negative or undesirable attributes. On the other hand, producers always have an incentive to disclose information that is advantageous to them. In addition, when labeled information has a "public good" attribute, a producer will be reluctant to label because he will bear the cost, but the whole industry will share the benefits (Golan *et al*, 2001).

The most important factor that drives a producer's labeling decision is consumer differentiation. Consumers are differentiated by preference, risk perception and education, among other factors. A producer's labeling decision is based on his expectation that consumers will respond to the labeled information by changing their consumption decision.

Third-party services are vitally important under a voluntary labeling approach (Golan *et al*, 2001). Because such an approach allows individual producers to decide on their own what and how to label, claims could vary greatly among firms. More importantly, the label's credibility could be doubtful. Independent third-party services with a good reputation can help to ensure the credibility of voluntary labeling. The third party could be sponsored by consumer groups, producer associations, governments or national or international organizations. The third party organization can offer services such as standard setting, testing, certification and enforcement to facilitate market transactions and increase market efficiency (Golan *et al*, 2001). This is the approach taken by the organic industry, which developed voluntary third-party systems in the 1970s and 1980s, although these systems have become mandatory in recent years in many countries.

2.5 Summary

This chapter provides a survey of some of the research on GMOs from their introduction as a new biotechnology, their wide application and development in agriculture, the role of critical food crisis events and the initiative for labeling regulation. Consumers' attitudes toward GMOs and labeling in different markets have been presented. With the demand for labeling, the economics of labeling has been discussed, as well as implications behind both mandatory and voluntary labeling. The next chapter further discusses the application of different GMO labeling policies.

Chapter 3: Labeling GMOs

3.1 The Rationale for GMO Labeling

The application of genetic modification to agriculture has developed dramatically over the past decade. The development, however, has raised substantial debate about governmental policies for regulating the marketing of GMO products with regard to their credence characteristic. Labeling policy can be a tool to help reduce market deficiencies caused by information asymmetry between producers and consumers. There are considerable differences in international approaches to GMO labeling; the two main types of labeling policies are mandatory labeling of GMO content, and voluntary labeling of GMO content or its absence. It is essential to examine the rationale behind these different labeling approaches.

Consumers' Right to Know

The past decade has seen a repeated assertion of the consumers' right to know as grounds for labeling GMO foods; the right to know has been identified as the most important rationale for demanding labeling of GMOs (Caswell, 2000). This argument is based on the concept that consumers have a right to sufficient information on a label to enable them to make informed food purchasing decisions. Trans Atlantic Consumer Dialogue (TACD, 2000) believes that consumers have a fundamental right to know what they are eating, such that all food products related to GMOs should be labeled. David Byrne, European Commissioner for Health and Consumer Protection, publicly stated that consumers are entitled to information about what they purchase and consume, and that consumers have the right to decide whether or not to purchase food products derived from genetic modification. Consumers have diverse preferences and risk perceptions, and therefore should have a right to choose or reject products based on adequate information (Fulponi, 2001). It has largely been consumers' demand for information that has led to governmental regulations on mandatory labeling of GMO food products.

Substantial Equivalence

In 1998, the Codex Committee on Food Labeling considered adopting the principle of "substantial equivalence" as a component in the Codex international standard for labeling GMO products. Under the "substantial equivalence" approach, the structure of the safety assessment is determined by comparing the new food to its conventional counterpart. In terms of its application to biotechnology, this concept is used to determine whether the genetically modified products are meaningfully different from their traditional counterparts (which are deemed to be safe) in composition, nutrition, taste, color, etc. If a GMO product sufficiently resembles a traditional product, that is, if a product containing GMOs is demonstrated to be substantially equivalent to its conventional counterpart, then the GMO product can be deemed as safe as its counterpart (Stilwell and Dyke, 1999). This concept is based on the philosophy that no food is absolutely safe, so food safety can be assessed only on a relative basis. "Substantial equivalence" was once considered to be the most appropriate approach for assessing the safety of foods derived from biotechnology (WHO/EURO, 2000).

The approach, however, has been widely criticized for not providing an adequate basis for testing GMO products' safety. Codex (2000) believes that the evaluation of GMO products' safety should be based on science and should follow a structured and rational approach. It was pointed out that the principle of "substantial equivalence" should be used only in the context of safety assessment, but is not appropriate in food labeling (ALINORM 99/22A). As a result, Codex did not endorse "substantial equivalence" as the international standard for labeling GMO products.

The US regulators believe that safety assessment should focus on products' characteristics rather than how the products are processed, and the concept of "substantial equivalence" provides a useful approach for assessing the characteristics of new products, including GMO products. Based on this concept, the US labeling policy requires a label only if consumers need to be alerted to any safety issues. In the case of GMOs, a label is required only if a GMO product is found to be substantially different from its conventional counterpart.

Precautionary Principle

The "precautionary principle" has been widely applied in environmental protection. It is used as a guide for managing environmental risk when scientific knowledge is not sufficient and complete to predict any possible harm from a proposed activity or technology. This principle's concept is that if a proposed activity carries with it any possible harm to the environment, even though the harm is not completely proven, the activity may not be permitted. The "precautionary principle" is essentially a "better safe than sorry" approach, when society does not want to find out the activity's harm later (Puttagunta, 2000).

The application of the "precautionary principle" to GMOs began at the 1992 Convention on Biological Diversity. Consumer groups who opposed GMO products argued that, in light of the scientific uncertainty about GMO products' potential long-term health risks and environmental damage, the "precautionary principle" should be applied in GMO labeling policy (Chaitoo and Hart, 2000; Moschini, 2001). By recognizing that the scientific evidence about such risks and uncertainties is incomplete and inconclusive, the precautionary approach can protect society from exposure to the risks and uncertainties posed by GMOs (Stilwell and Dyke, 1999).

Critics have argued that the principle is more a manifesto than a consistent and applicable principle, and that it can be used as a technical barrier to international trade. Another concern is that the principle's use could marginalize the role of science. Over-regulation using the "precautionary principle" could stifle GMOs' potential benefits. For example, overregulation of GM crops could reduce the production of high-yield crops and nutritionally enhanced foods.

3.2 Benefits and Costs of GMO Labeling

For simplicity we generally consider two main GMO labels: a presence claim and/or an absence claim.

Benefits

The primary function of labeling a credence product is to provide consumers with full information about the product's invisible attributes to help them make an informed consumption decision. Labeling can help consumers who wish to accept or reject GMO products to identify the right product. Consumers who accept GMO products can enjoy a lower price, due to the presumed lower production cost from the use of biotechnology, or a new product characteristic that results from genetic modification. Consumers who reject GMOs can avoid them if they are labeled as such. The size of the benefit from labeling is determined by the importance consumers attach to the labeled information. The information can be important to either a large number of consumers or a small segment of consumers (Teisl & Caswell, 2003).

The claim of the absence of GMOs can benefit non-GMO producers by allowing them to capture market share among consumers with high resistance to GMOs (Golan *et al*, 2001). Because the EU, Australia and Japan regulate the sales of GMO products, non-GMO labeling can help non-GMO producers to meet those regions' import requirements. In addition, non-GMO producers may even gain some price premium for providing non-GM products. Huffman *et al* (2003) used experimental auction methods to explore consumers' willingness to pay for GMO products, and found that consumers were willing to pay about a 14% premium for non-GMO items.

Costs

On the other hand, labeling GMOs adds all the usual costs that come with other labeling programs: standard setting, testing, certification and enforcement (Golan *et al*, 2001). There is a certain content threshold in different jurisdictions above which the presence of GMO material must be labeled. Therefore, testing for the presence of permitted GMO materials is a "must-do" practice to ensure compliance. The lower the tolerance level, the more expensive the testing. A third party is also required to monitor the regulations' enforcement.

An effective labeling regime requires that non-GMO products be clearly distinguishable from GMO products. There are two assurance systems to do this. The first is a segregation system which physically segregates GMO and non-GMO products throughout the whole supply chain, from seed production to supermarket shelves. Special handling may be needed to maintain segregation of genetically modified and traditional products during the production process. The second system is Identity Preservation (IP). IP is a system that tests and certifies the integrity and purity of agricultural products during production, handling and marketing to enhance the final products' value (Sundstrom *et al*, 2002). The application of IP in a labeling system provides certification to ensure the label's credibility. According to Bullock *et al* (2000), two crucial factors determine the major costs of segregation and IP: the tolerance levels set by governments and the preference levels set by consumers. Their findings suggest that without segregation and IP, consumers' concerns about GMOs' potential risks could lower the demand for both GMO and non-GMO products, because consumers could not distinguish non-GMO products from those that use GMOs. With segregation and IP, however, consumers can identify products so at least the demand for non-GMO products could increase. The cost, however, must still be considered.

According to Gruère and Rao (2007), KPMG International (2000a) published a report estimating the cost of implementing mandatory labeling in Canada, and found that it would amount to US $35 to US $48 per person per year. Jaeger (2002) thinks this estimate too high. In another report for Australia and New Zealand, KPMG (2000b) estimated that the total cost of labeling would amount to US $9.75 and US $2.6 per person per year, respectively. Jaeger (2002) conducted a cost study regarding the cost of implementing the mandatory labeling policy in Oregon, and found that the total cost would range from US $3 to US $10 per person per year. Cloutier (2006) provided a cost study for implementing a mandatory labeling policy in Quebec, and reported that the total setup cost would amount to US $20 per person, and that the variable cost after implementation would amount to US $3.5 per person per year. These estimates are lower than KPMG's figures.

3.3 Mandatory vs. Voluntary

The primary objectives of a mandatory labeling policy are to provide consumers information, facilitate consumer choice and meet the requirements of consumers' "right to know" about a product's attributes (Fulponi, 2001). Carter and Gruère (2003), however, provide a different perspective on this issue. They believe mandatory labeling can facilitate only producer choice, and not consumer choice. They point out that, according to Kalaitzandonakes and Bijman (2003) and Bernauer and Meins (2001), GMO products have disappeared from supermarkets' shelves in countries that have adopted mandatory labeling, such as countries in the EU, Japan, Australia and New Zealand. They argue that this shows that mandatory labeling cannot facilitate consumer choice, and actually constrains consumer choice. As to why this has happened, they suggest that strong opposition to GMO products in those areas forced producers of GMO products to decide to shift away from using GMO ingredients. It turns out that shifting to non-GMO products did not significantly increase costs for most products because, in any processed food product, the use of GMO ingredients is very small, and therefore has a small impact on the total cost. According to experimental studies (Tegene *et al*, 2003), consumers perceive GMO labels as a negative signal, so it is expected that the market share for GMO products will decline under a mandatory labeling policy. Thus, under mandatory labeling, most processors will choose to produce non-GMO products because they face a low expected market share and lack a significant profit incentive for producing GMO products. As Carter and Gruère (2003) argue, it seems plausible to say that mandatory labeling provides producers a choice about whether to produce GMO or non-GMO products, which, in fact, leaves consumers with no choice. Miller (1999) also indicates that stringent labeling may not be in consumers' best interests. Once a new product is heavily regulated by government, it will inevitably deliver the negative connotation to consumers that the product is not safe enough and is different from an unlabeled product (Miller, 1999; Bhatia and Powell, 2000).

Mandatory labeling means segregating and labeling products at all stages, which is believed to be impractical because it imposes excessive costs on suppliers at all levels, and then reduces the products' competitiveness (Bhatia and Powell, 2000; Miller, 1997). Therefore, it is sometimes argued that mandatory labeling could be used as an instrument for trade protection because of its impact on international trade. Voluntary labeling, on the contrary, can benefit producers (Phillips and Isaac, 1998) because it allows producers to choose to provide and signal the presence of desired attributes for which consumers are willing to pay. In the long run, consumers can benefit from innovations from the science of biotechnology under voluntary labeling.

A voluntary labeling regime leaves labeling decisions to producers. Producers have two options: either label the use of GMOs, or the non-use of GMOs (Caswell, 1998). Producers can be expected to voluntarily provide information on positive attributes that they believe will increase sales, and to avoid signaling negative attributes. Due to public perceptions about GMOs, it is highly unlikely that GMO producers will voluntarily label GMO-based products as such (Phillips & Isaac, 1998), because consumers generally consider GMO-based products as potentially "unsound" or "unsafe" (Kirchhoff and Zago, 2001).

3.4 International Approaches

In recent years a number of countries have adopted labeling policies for GMO products, and consumers' divergent attitudes toward GMOs have been reflected in different regulatory approaches. The first GMO labeling policy was introduced by the European

Union (EU) in 1997 (Regulation EC No 258/97), but since then many other jurisdictions have adopted some form of labeling policy for GMO products as well. Based on the regulations' stringency, three groups have emerged (Gruère & Rao, 2007). The EU group represents the most stringent process-based mandatory labeling approach. Japan and Australia have mandatory labeling requirements based on differences in the finished product, with higher threshold levels. The United States and Canada have adopted a product-based voluntary labeling approach for GMO or non-GMO food, as have Hong Kong and South Africa. Most developing countries have not fully implemented regulations on GMOs.

The European Union

In 1997 the EU adopted a GMO labeling policy that required all member countries to enact a law requiring the labeling of the presence of DNA or protein resulting from genetic modification. For products consisting of a mixture of GMOs and organisms not genetically modified, the possible presence of GMOs must be indicated. Under the EU labeling system that was introduced in September 1998, a product that contains GMO ingredients has to be labeled as such (Council Regulation –EEC, 1139/98). Non-GMO products do not have to be labeled, but suppliers have to take demonstrable measures to ensure that the ingredients are non-GMO (Nunn, 2000). However, the notion of non-GMO or GMO-free does not mean a level of zero GMO content in a product. In the EU, any food product derived from, or containing ingredients more than 1% of which are, GMO must be labeled "GMO" (Bullock *et al*, 2000). In January 2000 the labeling requirement included animal feeds derived from GMOs. In April 2000 the labeling policy was extended to include GMO additives and flavorings used in food. The impurity threshold to indicate "GMO-free" in a product was set at 1% of food ingredients. In July 2003, new EU rules on labeling and tracing genetically modified foods were officially adopted, which require food and animal feed to be labeled if they contain at least 0.9% GMO ingredients. Producers are required to store data about the origin, composition and sale of GMO products for five years, which could be the toughest GMO food regulation in the world. This new rule was widely welcomed by consumer rights and environmental groups. Yet, some believe that the strict low tolerance level of GMO content is not practical because the testing methods for such a low level are complicated and expensive (Chaitoo & Hart, 2000).

The EU's new regulations for GMO food and feed, which came into force in the EU on April 18th, 2004, are the world's strictest and most comprehensive regulations for labeling GMO food and feed (CORDIS News, 2004). There are two major changes compared to previous labeling provisions. First, genetically engineered feed must be labelled and second, all products derived from GMO ingredients must be labelled, regardless of whether they can be detected in the final product. Under the new regulations, no GMO products are allowed to enter the EU market unlabelled. Because consumers largely reject GMO foods, the vast majority of EU food producers and retailers have stopped using GMO ingredients in their food products sold within the EU. This sends a strong message to commodity exporting nations such as the US, Canada, Argentina and Brazil, which have resisted mandatory labeling. According to Lorenzo Consoli from Greenpeace's British office (Coghlan, 2002), this meant an end to the opportunity for some countries to effectively send millions of tonnes of unlabelled GMO products into the EU.

<u>Other Countries Following the EU</u>

All the following countries have pledged to introduce some form of mandatory labelling system: Australia, New Zealand, Brazil, China, Israel, Japan, Chile, Norway, the Philippines, the Republic of Korea, Russia, Saudi Arabia, Switzerland, Taiwan and Thailand (Greenpeace website). Most recently, India has also proposed to implement a GMO labeling policy (Gruère and Rao, 2007).

In October 1999 the Australia-New Zealand Food Standards Council (Ministers of Health) agreed to implement a strict mandatory labeling system for genetically modified foods and products containing GMO ingredients, with a threshold of 1%. In March 2001 South Korea implemented mandatory labeling for genetically modified corn, soybeans and bean sprouts, with a threshold of 3%. In April 2001 Japan established mandatory labeling for domestically produced and imported foods, except additives and animal feed. Japan uses a 5% threshold and relies on management controls to segregate GMO and non-GMO goods, rather than testing for GMOs, which is more practical than the EU's procedure. Thailand and Indonesia have followed Japan, both with a threshold of 5%. Other countries such as China and Brazil belong to the EU group and have implemented mandatory labeling policies covering certain products, China with a threshold of 0% and Brazil at 1%. China is the only large developing country with a labeling system effectively in place.

The United States

The United States is one of the six big growers of GMO crops, with 54.6 million hectares in 2006. The bodies responsible for regulating biotechnology in the United States are the US Department of Agriculture (USDA), the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA). The FDA, an agency of the Department of Health and Human Services, is responsible for enforcing food labeling laws and regulations to ensure the safety of food and food additives under the Federal Food, Drug, and Cosmetic Act. When the first GMO food products went to market in the United States in late 1994 and early 1995, much discussion arose about GMOs and labeling (Marshall, 1998). In 1992 the FDA published its "Statement of Policy: Foods Derived from New Plant Varieties" (Draft Guidance for Industry, 2001). The 1992 policy applies to foods developed from new plant varieties, including varieties developed using rDNA technology; but does not require special labeling for bio-engineered foods, and applies the labeling requirements for all foods to foods produced using GMOs (this policy also applies to animal feeds and plants developed by bioengineering). However, Section 201 (n) of the Federal Food, Drug, and Cosmetic Act sets up the requirements for labeling if a bio-engineered food is different from its traditional counterpart in characteristics such as composition or nutrition, in which case a label is required. If a food contains a known allergen, it must be shown on the label; or if a food has a usage issue or involves use consequences, this must be made clear on the label. Many commentators have expressed concern about the potential long term consequences of consuming GMO foods, but no scientific evidence has shown that GMO foods or ingredients have harmful effects that would require special labeling according to Section 201 (n) of the Act. In this case, the FDA's stance is that the industry can provide information on bio-engineered food products voluntarily. In general, the US has taken the position that any requirement for labeling must be "science-based."

The US GMO labeling policy is not a "process-based" but a "product-based" approach, which applies only when biotechnology has been involved to alter a product's end-use attributes (Miller, 1999b; Phillips and Isaac, 1998). If the end-use attributes have been altered, then consumers should be able to distinguish a GMO-based product from non-GMO-based products. Based on this reasoning, the US applies the "substantial equivalence" principle in its labeling policy. If existing food products derived from GMOs are substantially equivalent to traditional ones, then there is no need to label (Miller, 1999b). According to Caulder (1998), overwhelming scientific evidence suggests that GMO-based food is no different from non-GMO food. For example, soybean oil and soybean meal derived from RR soybeans and traditional soybeans were essentially the same, so regulations should treat the two soybeans the same (Moschini, 2001). Otherwise, because about 8,000 end food products are derived from soybeans, Caulder (1998) argued that it would be unrealistic to label each one individually only because genetically modified soybeans may have been used somewhere in the production process. Bhatia and Powell (2000) argue that the risks associated with GMOs are believed to be the same as those of other products produced traditionally. Labeling should identify known risks instead of the hypothetical ones. From the FDA's perspective, the current labeling approach ensures consumer safety. For example, Pioneer Hi-Bred International produced a recombinant soybean for animal feed that contained an allergenic protein transferred from Brazil nuts. Pioneer Hi-Bred identified the allergen before releasing the product. According to the FDA labeling approach, such information must be labeled on all consumer products which use this new kind of soybean. Considering the potential product liability and the related labeling costs, Pioneer Hi-Bred finally canceled the project (Miller, 1999).

Canada

In Canada, the responsibility for food labeling policies is jointly shared by Health Canada and the Canadian Food Inspection Agency (CFIA) under the Food and Drugs Act. Health Canada is responsible for developing policy and setting standards related to public health, food safety and nutrition (Health Canada website, 2006). CFIA is responsible for the administration of food labeling policies to ensure enforcement and credibility, so CFIA has responsibility to protect consumers from misrepresentation and fraud with respect to food labeling.

In terms of GMO food labeling policy in Canada, voluntary positive and voluntary negative labeling is permitted, provided the labeling is truthful and not misleading. Food products developed from genetic modification that are demonstrated to be safe, are treated the same as conventional products. With regard to the food safety assessment in Canada, a food product is assessed according to its own characteristics, rather than the production method. Mandatory labeling of foods is necessary only when significant nutritional or compositional changes have been made in comparison to conventional foods, or when consumers need to be alerted to a potential health or safety risk, such as allergens, resulting from consuming GMO-containing food products. Otherwise, a voluntary labeling approach has been used, provided the labeling is truthful and not misleading (Chaitoo & Hart, 2000). To facilitate the application of voluntary labeling of food products derived from GMOs, the Canadian Council of Grocery Distributors sponsored the creation of a standard to provide guidance. This voluntary standard was developed through the Canadian General Standards Board, and adopted as a National Standard of Canada in April 2004 (Health Canada website, 2006).

Codex Alimentarius Commission

The international institutions that have been directly involved in discussions over GMO labeling are the Codex Alimentarius, the Biosafety Protocol and the World Trade Organization (WTO). The Codex is responsible for establishing health, safety, labeling and other food standards to ensure food safety among members of the United Nations (Tower, 1995; Bhatia & Powell, 2000). Two objectives of Codex are to implement the joint FAO/WHO[1] Food Standards Program, and to harmonize standards across nations in order to facilitate trade. The Codex Committee on Food Labeling (CCFL) has been working on GMO labeling since the early 1990s, attempting to develop a standard framework for its member countries. As of 2007, no international consensus on GMO food labeling has been reached.

[1] Food and Agricultural Organization /World Health Organization.

The Codex process of attempting to develop an international consensus on GMO labeling standards has demonstrated the complexity of reaching the objective. The whole process started at the 22nd Session of Codex in 1993, and in 1997 at the 25th Session, a recommendation document was introduced, which is the "Proposed Draft Guidelines for the Labeling of Food and Food Ingredients Obtained through Certain Techniques of Genetic modifications/Genetic Engineering" (Codex, 1997). The guidelines provide no formal standard on labeling, but they do provide a basis for discussion. The guidelines suggest the following:

- Labeling should be required for GMO food that is not substantially equivalent to conventional food.
- Labeling should be required if the GMO food contains allergens.
- Labeling should be required for substances with physiological or metabolic impacts.
- Labeling should be required to indicate the production process.
- Labeling should be required if GMO products raise religious or dietary concerns.

In the following years, in an attempt to reach an international concensus, Codex has held annual sessions to discuss the proposed draft recommendations, in addition to the work of various task forces and working groups. There have been some accomplishments in developing labeling standards, but there is still a long way to go for the CCFL to meet its objective.

3.5 Implications

Countries with a high percentage of GMOs in their total food production, such as the US, Canada and Argentina, have adopted voluntary labeling; while the importing countries, such as the EU's member nations, have tended to adopt mandatory labeling. This is a matter of fact that reflects each jurisdiction's different economic interests. The US, Canada and Argentina grow about 77% of the world's GMO crops (ISAAA, 2006), which gives these countries the biggest stake in commercial sales and international trade. Meanwhile, the major importers such as the EU and Japan grow small amounts or no GMO crops. The current use of GMO biotechnology in agriculture remains at the "first generation," or producer level, and it can bring producers benefits such as reductions in production costs and increased yields. The main beneficiaries include farmers, seed suppliers, technology innovators and sellers, while consumers cannot benefit directly although consumers will eventually benefit when production costs fall drastically and yields increase. Once biotechnology is used to develop products with attributes that consumers desire, such as better nutritional characteristics or better taste, consumers may have a different perspective on the use of GMOs.

Some theoretical economic studies (Kirchhoff and Zago, 2001; Chaitoo and Hart, 2000; Crespi & Marette, 2003; Giannakas & Fulton, 2002; Fulton & Giannakas, 2004) have shown that mandatory labeling could benefit countries where a large majority of consumers are GMO-averse and are willing to pay more for GMO-free products. In the EU and Japan, for example, the labeling requirements were initiated in response to consumers' strong opposition to GMO products. GMO products were targeted by anti-

GM organizations and, as a result, it is more profitable for companies there to avoid GMO-related products than to produce and label them. In countries where GMO producers are common and consumers are little concerned about GMOs, but are more concerned about the cost savings resulting from biotechnology, a voluntary labeling scheme would be optimal for the public The main reason that voluntary labeling is preferable to mandatory labeling in heavily producing countries is that producers have higher market shares under voluntary labeling than under a mandatory system. This is because mandatory labeling distributes additional labeling costs among all consumers, but the costs of voluntary labeling are imposed on GMO-free consumers only. Chaitoo and Hart (2000) also suggest that voluntary labeling may be more efficient when only a small segment of the population is interested in food products involved with GMOs, and is willing to pay more for products carrying this information. But if the majority of the public wants to know, then mandatory programs may be more effective.

Another significant implication of the different GMO labeling policies adopted in different countries is on international trade, because they can be used as a part of countries' strategic trade policy to restrict imports and exports. As the largest exporter of GMO-based products, the US government argues that the mandatory labeling policy enacted by the EU and some countries has no scientific basis, and acts as a non-tariff barrier to disrupt international trade because it imposes a labeling cost "tariff" on US GMO product exporters (Crespi, 2003).

If a product is to be exported to a foreign market, it must meet local standards and regulations in order to gain market access, as long as these are consistent with international trade agreements. Because most major grain importing countries, such as the EU's members, China, Japan and Korea, have imposed mandatory labeling requirements on GMOs, if GMO exporters such as the US and Canada want to export GMO-based products to these markets, they must meet these various regulations. In these cases, mandatory labeling represents a significant barrier to market access. According to Zepedal (2002), countries that have enacted mandatory labeling used to import about 43% of US agricultural products before 1998. Since 1998, however, the EU has restricted imports of new varieties of GMO crops. GM Watch (2006) reported a massive drop in US soybean and soybean meal, as well as corn, exports to the EU. During the soybean marketing year from September 2005 to August 2006, US soybean exports to the EU were down from the previous year by 54%, and soybean meal exports fell 56%.

The major international markets for Canadian canola are Japan, Mexico, China and the US. Because the EU does not allow imports of GMO canola for use in food or feed, Canada lost the EU's canola market to Australia, which plants GMO-free canola. However, Canada has been recently exporting GMO-canola oil to the EU for use in Biodiesel, which is allowed under the EU regime, since it is being used for an industrial product, and not food. Since March 2002, China has requested that exporters of GMO products to China must obtain safety certificates from its Ministry of Agriculture certifying that the products are safe for human consumption, animal use and the environment. This new rule has reduced Canada's canola exports to China from the record high of nearly 2 million tonnes in 2000-2001 to nearly zero in 2002-2003. Exports were forecast to be 0.7 million tonnes in 2006-2007 (Statistics Canada, 2006). The dramatic drop in exports of GMO crops suggests that the mandatory labeling policy for GMO products has, in fact, acted as a market access barrier, which disrupts international trade, limits market size for GMO products, lowers potential returns and impedes further biotechnology investment.

3.6 Summary

This chapter has described the labeling of GMOs in several respects. First it examined the rationale for labeling based on consumers' right to know, the concept of substantial equivalence and the Precautionary Principle. Then it reviewed the application of these principles to GMO labeling approaches among different markets. The application of different rationales to GMO labeling policy is, in essence, a reflection of the cost-benefit evaluation by governments and stakeholders. Economists generally agree that mandatory labeling is optimal in markets with a majority of GMO-averse consumers and few GMO producers, and that voluntary labeling is optimal in markets with many GMO producers and price-oriented consumers.

Some economists have long argued that a mandatory labeling policy is not the best solution to provide consumer choice or consumer information, especially when it may affect trade (Phillips & Isaac, 1998; Runge & Jackson, 2003; Gruère& Rao, 2007).

Voluntary labeling, however, provides consumers with the option to choose between GMO and GMO-free products (Runge & Jackson, 2003). Some surveys, however, show that consumers do not trust the industry to voluntarily provide information under a voluntary labeling system (Globe and Mail, 2003). The next chapter explores how producers respond to a voluntary labeling approach in terms of their cost-benefit evaluations, and whether voluntary labeling should be used to achieve the government's policy goals.

Chapter 4: Negative Labeling under Voluntary Labeling Regime

4.1 Problem Statement

In Canada, there is still much debate on the appropriate labeling approach to regulate GMO food products, irrespective of the fact that the government has adopted a voluntary labeling policy. An overwhelming majority of Canadians believes that GMO food products should be labeled as such (Chase, 2003). A poll conducted by Decima research (which was paid by Consumers Association of Canada) in October 2003 surveyed 2,000 people and found that over 90% of Canadians wanted the use of GMO to be labeled, and 88% supported a mandatory labeling policy (Moore, 2003). However, Donald Boulanger, spokesman for then Canadian Agriculture Minister Lyle Vanclief, said that the government trusted that companies would respond to consumer concerns by voluntarily labeling GMO food products. He said companies will label products as GMO-free as per consumers' demand (Chase, 2003). Peggy Kirkeby, the vice-president at the Consumers Association of Canada, claimed that consumers simply did not trust that the food industry would voluntarily provide the necessary information (Chase, 2003).

In the literature, there are many theoretical and empirical studies of consumers' perceptions on GMO food labeling. However, there are few that have examined producers' interests on labeling (Chembezi *et al*, 2005). This chapter is intended to provide a theoretical approach to explore, under a voluntary labeling policy, how producers are going to respond, and what market factors will contribute to producer labeling decision making.

In principle, under a voluntary labeling regime, producers can either label their products to be GMO (positive labeling) or non-GMO (negative labeling). Runge and Jackson (2000) point out that a positive label would perform like a risk warning to consumers, just like the label on cigarettes, and thus provide misleading information that would prevent consumers from making correct decisions. A number of other authors have also claimed that a positive label claiming the presence of GMOs is perceived by consumers as a negative signal, and may be as helpful to consumers as having no label at all (Miller, 1999; Rousu *et al.*, 2003; Carter and Gruère, 2003). Negative voluntary labeling, however, may be a better solution. Negative voluntary labeling means that producers of traditional foods can choose to label their products as non-GMO or GMO-free. GMO-based products would not have to be labeled. Compared to labels such as "contains GMO", generally consumers interpret a "GMO-free" label as a signal that the product is "safe", that is, it is free of the uncertainty associated with a product that contains GMO (Kirchhoff and Zago, 2001). Therefore, it is generally expected that with voluntary labeling, only non-GM products will be labeled (Hu *et al.* 2004).

Runge and Jackson (2000) believe that a negative labeling claim such as "No GMOs" or "GMO-free" are beneficial to both producers and consumers. Producers may benefit through increased sales through this strategy, and consumers can avoid receiving information biases associated with positive labeling. They provide the case of rBST (recombinant bovine somatotropin) labeling in the U.S. dairy sector to illustrate that a negative voluntary labeling strategy may be a solution to the GMO labeling controversy. rBST is a genetically-engineered version of a naturally-occurring growth hormone in dairy cattle, the use of which aims at increasing milk production. However, consumer groups and some farmers refused to adopt the product. Following the adoption of negative labeling, the sales of companies such as Land O'Lakes jumped substantially. Runge and Jackson argue that this successful example can also be applied to other related issues such as GMOs labeling. Many US manufacturers are already using GMO-free labels to increase sales or prevent sales losses due to consumer concerns about GMO products. Examples include Nestle, Gerber, Heinz, FritoLay, McDonald's, and Iams, all of which have all banned GMO ingredients in some food lines, especially in those consumed by children and pets (Zepeda, 2001). In addition, GMO suppliers will find this labeling regime to be attractive, because it shifts the burden of the costs of labeling to those who sell traditional foods, which will make labeled traditional foods more expensive and therefore create a built-in market bias in favour of GMO producers.

4.2 Related Studies

Giannakas and Fulton (2002) developed a model to examine the effects of genetically modified foods on consumer welfare and purchasing decisions under several scenarios: no labeling, mandatory labeling under full compliance and mandatory labeling with mislabeling. In the model, they assume consumers have the options of consuming either traditional, GMO or a substitute product. They consider consumer heterogeneity in preferences – notably the level of aversion towards GMO products. Their findings suggest that if consumers perceive GMO products to be different from the traditional ones, then there exists the demand for labeling the GMO products. For consumers, the relative welfare ranking of the 'no labeling' and 'mandatory labeling' regimes depends on the level of aversion to GMO products, the different market prices consumers may face under alternative labeling approaches, the extent of mislabeling by GMO producers, and the market share of GMO products to total consumption. Although their focus is on consumer welfare, and they do not consider producers' choices, their analysis of consumer consumption choices can be used to analyze producers' labeling decision. As under a voluntary labeling regime, the question for GMO producers is whether consumers will continue to purchase the products once their products are labeled genetically modified (Chembezi *et al.* 2005).

Kirchoff and Zago (2001) have also conducted a study to examine the welfare effects of different labeling systems. Their study discussed both mandatory and voluntary labeling policies, and the welfare impact of the two different policies on both consumers and producers. Consumer heterogeneity is also assumed here. However, different from Giannakas and Fulton, they use consumers' valuation of non-GMO products instead of aversion to GMO-based products. An important assumption they make is that firms earn zero profits, in other words, the market price is determined by marginal cost. Thus, producer's choices are dependent on whether they can gain higher market share. In comparing the different costs consumers face under different labeling regimes, Kirchoff and Zago assume that under a mandatory labeling system, the government would be responsible for all the costs associated with monitoring and enforcement to ensure compliance. However, they assume that these costs will finally be shared by all consumers, as government will levy a tax on all taxpayers to cover the costs. In contrast, under a voluntary labeling system, since only non-GMO producers will label their products, then the costs will be borne by these producers and finally passed to consumers who buy the non-GMO products. Their findings show that under mandatory labeling, consumers pay less for GMO-free goods while they pay more for GMO-based goods as compared to the voluntary labeling system. In other words, under a voluntary labeling system, consumers would switch to consume GMO-based products given the conditions in the study.

Rousu *et al.* (2003) developed a model to compare the consumer welfare under alternative labeling systems, attempting to examine the potential welfare effects of imposing a mandatory GMO labeling policy in the United States. They designed an experiment to test consumer purchasing behavior by dividing consumers into two groups: one group with a mandatory labeling policy and the other one with a voluntary labeling policy. Their model differs substantially from Kirchoff and Zago (2001) in that they assume under a mandatory labeling policy, producers would themselves bear the costs associated with product testing, label design and segregation, etc. Their results conclude that in the US, a voluntary labeling policy is superior to mandatory labeling as voluntary labeling policy is less expensive, and the a mandatory labeling policy for GMO foods results in welfare losses relative to a voluntary labeling policy.

Hu *et al.* (2005) studied the impacts that different GM labeling policies may have on consumers and on measures of social welfare by examining Canadian consumers' response to GM products. They used data collected from an internet-based CBC survey (choice-based conjoint approach, known as the CBC approach). Their findings showed that consumers are more averse toward the GM products under a mandatory labeling policy than under a voluntary or no labeling system.

Kiesel *et al.* (2003) assessed the effects of voluntary labeling on consumer choices over different milk products: labeled and unlabeled biotech-free fluid milk products, conventional and organic brands. They examined the effect of the use of rBGH on aggregate fluid milk consumption in major US cities by using supermarket scanner data. They used a model that incorporates the key elements of product attribute models with those of advertising and search models within a random utility framework. In the model, they assume that consumers receive utility from consuming rBGH-free milk products. The results of their study indicate that the positive effects of labeling on the demand for rBGH-free fluid milk have increased over time (comparing the period 1998-1999 to the period 1995-1997). They conclude that additional positive labeling will increase consumption of the commodity with a desirable characteristic and reduce consumption of a competing commodity with an undesirable characteristic.

Although all these studies have different foci, and make different assumptions, their conclusions are very similar. They agree that mandatory labeling would be optimal in markets with GMO-averse consumers and GMO-free producers, while voluntary labeling would be optimal in markets where GMO producers are dominant and consumers are more concerned about the market price. Still, most literature focuses on examining consumer welfare under different labeling approaches and does not explore production effects of GMOs under different policy systems. Although Kirchoff and Zago (2001) take into consideration different types of producers' preferences, they just present a very simple discussion. The following sections provide a theoretical analysis of the case of negative labeling by non-GMO producers under a voluntary labeling policy. The approach applied here will follow the methodology used by Giannakas and Fulton (2002) in their analysis of consumers.

4.3 Producers' Profits with No Labeling

This analysis starts with a discussion of the profits producers receive when there is no labeling requirement in place. This is followed by an analysis of traditional producers' labeling decision strategy under the voluntary labeling system. Finally there is discussion on GMO producers' behaviour from the perspective of how GMO producers may respond to non-GMO producers' labeling strategy. The objective of both producers is to realize the maximum profits under the voluntary labeling regime.

(1) Assumptions

Consider a market with both GMO and non-GMO products where producers are differentiated as some produce a non-GMO product and some produce a GMO product. Giannakas and Fulton (2002) assume three types of products in the market: product with a GMO technology, product with a traditional breeding method, and a substitute. For example, margarine can be made from traditional canola or GMO canola, and the substitute is butter. Consumers can have three options. When consumers have difficulty in making a decision between traditional and GMO margarine, then they may switch to the substitute product – butter.

To keep the analysis simple, and to focus on the key issues, we only assume two products: products with and without GMO technology, so consumers only have two options. And, it is assumed that all GMO producers are homogeneous as well as non-GMO producers. Studies have shown that regardless of various factors (such as geographical location, farm size, product specialization, farm management skills, age, education, etc.), farmers generally benefit from the adoption of GMO technology due to input cost savings and increased yields (Fulton and Keyowski, 1999). Assuming that reduced production costs at the farm level can be perfectly spilled over to the supply chain, GMO producers have lower production costs than non-GMO producers.

(2) Utility Specification

Under voluntary labeling, producers' decision to label or not is essentially determined by two factors:

i. The labeling effects on market share. Whether consumers increase or decrease demand after labeling or simply stay with the same consumption will affect the producers' market share and their labeling decision.

ii. Profitability per unit of a final product sold. Producers will compare the unit profit margin before and after labeling to find out if they gain or lose from labeling (Carter and Gruère, 2003).

Producers make the labeling decision with the objective of maximizing profits. Producers' profits can be written as:

$$\pi_{gm} = (P_{gm} - C_{gm}) * Q_{gm} \qquad (1)$$

and

$$\pi_{ng} = (P_{ng} - C_{ng}) * Q_{ng}. \qquad (2)$$

where π_{gm} is the GMO producers' profits, π_{ng} is the non-GMO producers' profits. P_{gm} and P_{ng}, Q_{gm} and Q_{ng} are the unit market prices and quantities for GMO and non-GM products, respectively. Assuming GMO producers have unit production costs equal to C_{gm}, and non-GMO producers have unit production costs equal to C_{ng}, where $C_{gm} < C_{ng}$, for the same quantity produced, GMO technology lowers production costs compared with the conventional product. This is constructed under the assumption that the introduction of the new production and the cost savings are transmitted perfectly through the whole supply chain.

(3) Profits with No Labeling

Now consider a market where no products are labeled. Without labeling, GMO and non-GMO products are not distinguished and are marketed together. Therefore they are priced the same since consumers are unable to distinguish one product from another. Since GMO and non-GMO products are priced the same, assume their market price is set at $\overline{P}_t$, so $P_{gm} = P_{ng} = \overline{P}_t$. Since GMO and non-GMO products are marketed at the same price but with different input costs, then they have a different profit margin. Obviously, $\overline{P}_t - C_{gm} > \overline{P}_t - C_{ng}$, therefore, GMO producers receive greater unit margin than non-GMO producers. Assume $Q_{gm} + Q_{ng} = 1$. Since consumers cannot distinguish GMO from non-GMO products, they randomly purchase either GMO or GMO-free products, and therefore GMO and non-GMO producers evenly divide the entire market, i.e. $Q_{gm} = Q_{ng} = \frac{1}{2}$. Since GMO and non-GMO producers have the same market share, knowing that GMO producers earn a larger unit product margin, therefore in aggregate, producers receive greater profits by selling GMO-based products when no products are labeled. As we only assume products with two forms, i.e. GMO and non-GMO, if consumers with high level of resistance to GMO products have no way to distinguish one from the other and are aware of the existence of GMO products, then the demand for both GMO and non-GMO products will be reduced. Non-GMO products cannot charge a higher price as they are not signaled. This outcome will lead to the classic "lemons" problem (Akerlof, 1970). Eventually GMO products will drive out non-GMO products. Therefore, if some consumers in the market have an aversion to GMO products, then the "No Labeling" system results in a welfare loss.

4.4 Profits under Voluntary Labeling

(1) Assumptions

Now consider a voluntary labeling regime given that GMO and non-GMO products are not distinguishable from each other. It is assumed that if producers label their products as "GMO-free", then non-GMO products can be differentiated from GMO products, and consumers will presume that unlabeled products are GMO-based products. GMO and non-GMO products are segregated and marketed separately. Consumers now have a choice between a non-labeled GMO product and a labeled non-GMO product.

Assume consumer heterogeneity, such that they are differentiated in their attitudes toward GMOs. Some consumers are concerned about the potential risks or uncertainties while others are indifferent to GMOs. The diversity of consumers' attitudes suggests that if consumers perceive GMO products to be different from their traditional counterparts, then those with an aversion toward GMO products, do not want to be exposed to GMO products. Depending on the 'GMO-free' labels provided by producers, consumers will be able to identify non-GMO from GMO to make informed consumption decisions.

(2) Profit Specification under Voluntary labeling

If traditional producers want to signal their products to be "GMO-free" by providing the label, they will incur additional costs. First, they must label their products to be "GMO free" or "Contains No GMOs", which incurs the physical labeling costs such as label designing and printing. Second, there is a cost to segregate GMO and non-GMO products through the whole supply chain. Third, there is an Identity Preservation cost or monitoring cost. Since these companies are private and profit-oriented, consumers would be concerned that the labels might be fraudulent. Caswell and Mojduszka (2000) point out that the voluntary labeling information provided by producers is not necessarily reliable and complete. The credence characteristics of the product suggest that no signal is credible without third-party involvement because firms have an incentive to provide misleading information (Crespi and Marette, 2003). Even in countries with stringent product liability laws, fraud can still happen. Therefore, these producers have to pursue an identity preservation system to guarantee the integrity of the labeling. Whether under mandatory labeling or voluntary labeling, labeling should be accurate and truthful to consumers. In order to ensure full compliance, there has to be a system or an agent that monitors products and provides the enforcement. For example, under mandatory labeling, the government requires all GMO products to be labeled. The government or its delegate has to set up a system to monitor and enforce. Kirchoff and Zago (2001) assume that the monitoring costs are paid for by the government who will levy a tax on all tax payers. Under voluntary labeling, non-GMO producers themselves have to set up a system or go to a third-party agency for the monitoring. Assume that these costs will be borne by these producers only. Let C denote all the labeling costs per unit of a non-GMO product.

Assume that both GMO and non-GMO producers make the same unit profit margin as in the case of 'no labeling'. GMO products are still marketed at $\overline{P}_t$, but non-GMO producers will improve their product price just enough to cover the labeling costs. Now the GMO producers' profit is given by the following:

$$\pi'_{gm} = (P'_{gm} - C'_{gm}) * Q'_{gm} \tag{3}$$

where $P'_{gm} = P_{gm} = \overline{P}_t$, $C'_{gm} = C_{gm}$, and Q'_{gm} is the quantity sold after non-GMO producers label their products.

The non-GMO producers' profit is now given by the following:

$$\pi'_{ng} = (P'_{ng} - C'_{ng}) * Q'_{ng} \tag{4}$$

where $P'_{ng} = P_{ng} + C = \overline{P}_t + C$, $C'_{ng} = C_{ng} + C$, and Q'_{ng} is the quantity sold after the labeling.

As both GMO and non-GMO producers are assumed to have the same unit profit margin, therefore, it is the quantity of product sold, or in other words, the market share that will determine whether non-GMO producers should make the labeling decision. If non-GMO producers can gain the same or more market share after providing the label, then they will receive the same or more profits through labeling. That is to say, if consumers are willing to pay the full labeling cost specified in (4) or more for the labeled traditional products, then non-GMO producers will make the same or more aggregate profits compared to GMO producers who do not label. On the contrary, if it turns out that consumers are not willing to pay for the additional cost resulting from the 'GMO-free' label, then non-GMO producers will sell less quantity or lose market share by labeling. Then non-GMO producers will be made worse off. The purpose of the following sections is to analyze the changes of the traditional producers' market share to determine whether non-GMO producers would be better off or worse off if they provide the 'GMO-free' label. .

(3) Market Share with Fixed Unit Margin

Suppose that each consumer can purchase either one unit of GMO product or one unit of non-GMO product, but not both. Assume consumers receive the same basic utility from consuming either GMO or non-GMO product. The basic utility of consuming either GMO or non-GMO product is denoted as U, where $U > C_{gm}$. The intuition of the assumption is that if consumers receive less utility from the consumption than the purchasing price (in other words, the production cost), they would never purchase the GMO product. Consumers have preferences toward non-GMO products to varying degrees. Let $\rho\theta$ denote the preference level, where $\rho \in [0,1]$, assuming consumers are uniformly distributed with respect to their preference toward non-GMO products and θ is a parameter representing the maximum preference for non-GMO, with $U + \theta > C_{ng}$. This assumption suggests that if $U + \theta < C_{ng}$, then even the most GMO-averse consumer would never buy non-GMO products. Consumers with a low value of ρ are less concerned about the potential negative impacts of GMOs, while consumers with a high value of ρ are very concerned about the GMO products and prefer the non-GMO product. Consumers' utility is given by:

$U_{gm} = U - P'_{gm}$ if one unit of non-labeled GMO product is consumed

$U_{ng} = U - P'_{ng} + \rho\theta$ if one unit of labeled non-GMO product is consumed where U_{gm} is the utility associated with purchasing one unit of the GMO product, U_{ng} is the utility associated with purchasing one unit of the non-GMO product and $\rho\theta$ represents the increase in U that can be attributed to the consumer knowing that the product is non-GMO. From the above assumptions of $P'_{gm} = P_{gm} = \overline{P}_t$, and $P'_{ng} = P_{ng} + C = \overline{P}_t + C$, consumers' utility can be written as:

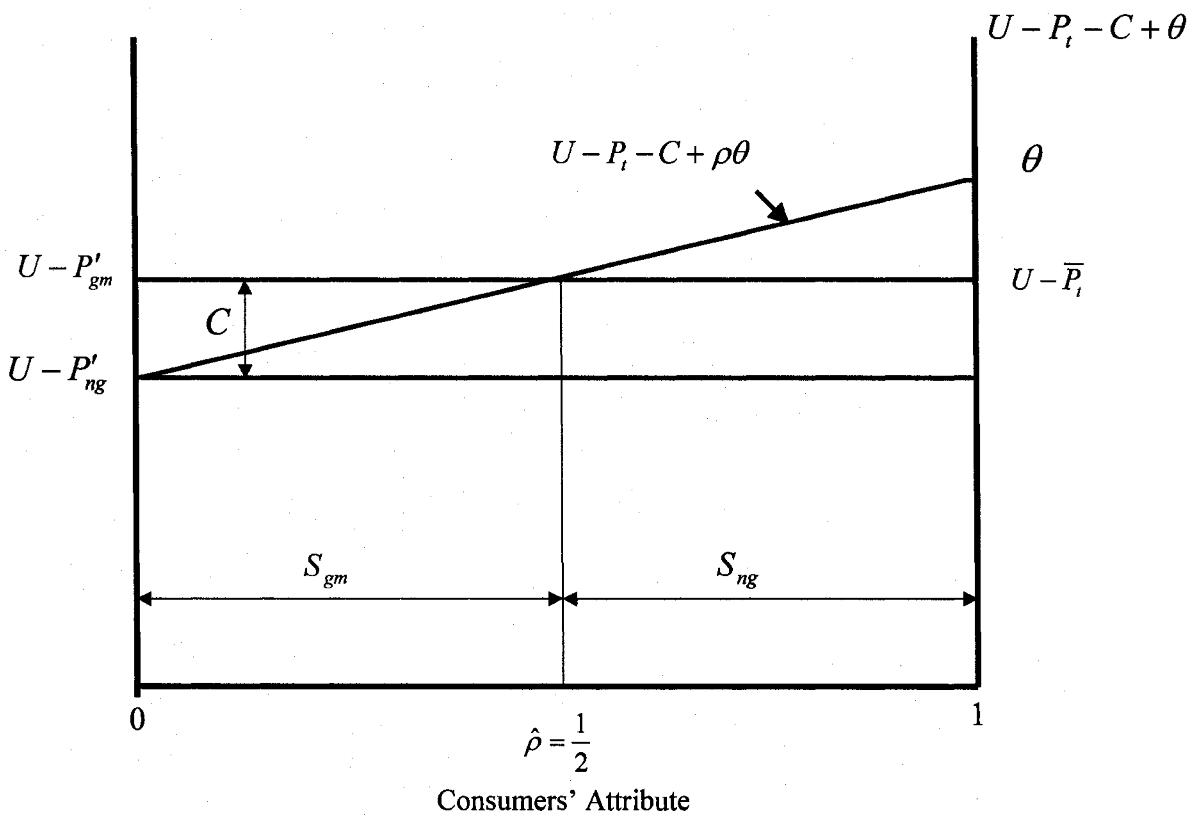
$U_{gm} = U - \overline{P}_t$ if one unit of non-labeled GMO product is consumed

$U_{ng} = U - \overline{P}_t - C + \rho\theta$ if one unit of labeled non-GMO product is consumed

C is simply a price premium to cover all the costs of labeling. Thus, consumers will choose to buy non-GMO products if ($U_{ng} = U - \overline{P}_t - C + \rho\theta$) > ($U_{gm} = U - \overline{P}_t$). Therefore, consumers with $\rho > \frac{C}{\theta}$ buy non-GMO products and those with $\rho < \frac{C}{\theta}$ buy non-labeled GMO products. Let $\hat{\rho} = \frac{C}{\theta}$ define the level at which consumers are indifferent between the non-labeled and non-GMO products. Since consumers have been assumed to be uniformly distributed with respect to the preference attribute ρ over the interval $[0,1]$, the indifference level $\hat{\rho}$ also determines the share of non-labeled product to total consumption, S_{nl}, which can be denoted by $S_{nl} = \frac{C}{\theta}$. The consumption share of the non-GMO products is given by $S_{ng} = 1 - \hat{\rho}$, which can be denoted by $S_{ng} = 1 - \frac{C}{\theta}$. This shows that the size of the segregation and labeling costs coupled with consumers' maximum preference parameter affect consumers' consumption decision. From the perspective of producers, the consumption share is exactly the same as the producers' market share. Therefore, to analyze producers' market share, we can analyze consumers' consumption share instead as the latter exactly reflects producers' market share. Any change in the consumption share for GMO and non-GMO products is directly related to the change in GMO and non-GMO producers' market share. The following figures use consumers' consumption share to determine the change in non-GMO producers' market share after labeling.

Figure 1 depicts consumers' consumption decision and producers' market share after non-GMO producers label their products as "GMO-free" and increase the market price by C. The horizontal line at $(U - P'_{gm})$ represents the utility associated with a unit consumption of the non-labeled GMO product, while the upward sloping line represents the utility associated with a unit consumption of the labeled non-GMO product for different levels of the differentiating attribute ρ. The intersection of the horizontal line ($U_{gm} = U - P'_{gm}$) and the upward sloping line ($U_{ng} = U - \overline{P}_t - C + \rho\theta$) determines the level of indifferent consumers $\hat{\rho}$, as well as the consumption share of the labeled non-GMO products and non-labeled GMO product. It is optimal for consumers located to the left of $\hat{\rho}$ to purchase the non-labeled GMO product while consumers located to the right of $\hat{\rho}$ to purchase the labeled non-GMO product. Consumers with $\rho \in [0, \hat{\rho})$ will receive higher utility from consuming the non-labeled GMO product and consumers with $\rho \in (\hat{\rho}, 1]$ will receive higher utility from consuming the labeled non-GMO product. Consumers' consumption decision also determines the GMO and non-GMO producers' market share respectively.

Figure 1 Consumption decisions and producers' market share with labeling



In Figure 1, assume $\hat{\rho}=\frac{C}{\theta}=\frac{1}{2}$, where consumers are indifferent to GMO and non-GMO products, so the consumption demand for GMO and non-GMO products are equal to each other. Thus, the amount of the labeling and segregation costs is just half of the consumers' preference parameter, $C=\frac{\theta}{2}$, then GMO and non-GMO producers will each take half of the market share, which is the same as the initial situation when there is no labeling. In this case, non-GMO producers are neither better off nor worse off by labeling. More specifically, if both GMO and non-GMO producers keep the same unit profit margin as under the no labeling regime, the relationship between the added labeling costs C and the preference parameter θ is crucial in determining the GMO and non-GMO producers' market share, as it determines the indifference level of $\hat{\rho}$. From Figure 1, it can be found that when $\hat{\rho} < \frac{1}{2}$, non-GMO producers have larger market share, while when $\hat{\rho} > \frac{1}{2}$, GMO producers have larger market share. Therefore, the relationship between the added labeling costs C and the preference parameter θ determines whether non-GMO producers gain or lose market share by labeling.

First, consider how a change in θ will affect non-GMO producers' market share. When consumers are very concerned about consuming GMO products, they have an increased preference toward non-GMO products, which has been reflected in reality that consumers' attitudes toward GMOs changed from initially backing the new technology to prevailing resistance over the past decade. While when consumers are assured about the safety and more consumer desirable attributes of GMO products, the preference toward consuming non-GMO products may decrease. Figure 2 and Figure 3 describe how a change in θ will have a impact on non-GMO producers' market share. Figure 2 depicts consumption decisions and producers' market share after an increase in the preference parameter θ for the non-GMO product for any level of ρ. An increase in θ will cause the non-GMO producers' U_{ng} to rotate upward to the new line U_{ng}. Now the indifference level $\hat{\rho}$ is determined by the intersection of the horizontal line U_{gm} and the new upward sloping line U_{ng}, and it can be found that now $\hat{\rho} < \frac{1}{2}$. The change in the figure shows that non-GMO producers obtain a larger market share, than under the no labeling regime given other things unchanged. GMO producers, on the other hand, suffer a loss in market share. Obviously, in this case, non-GMO producers gain market share and aggregate profits by labeling, and GMO producers lose profits. Therefore, as θ increases, it becomes more advantageous for non-GMO producers to label.

Figure 2. Consumption decisions and producers' market share after an increase in θ.

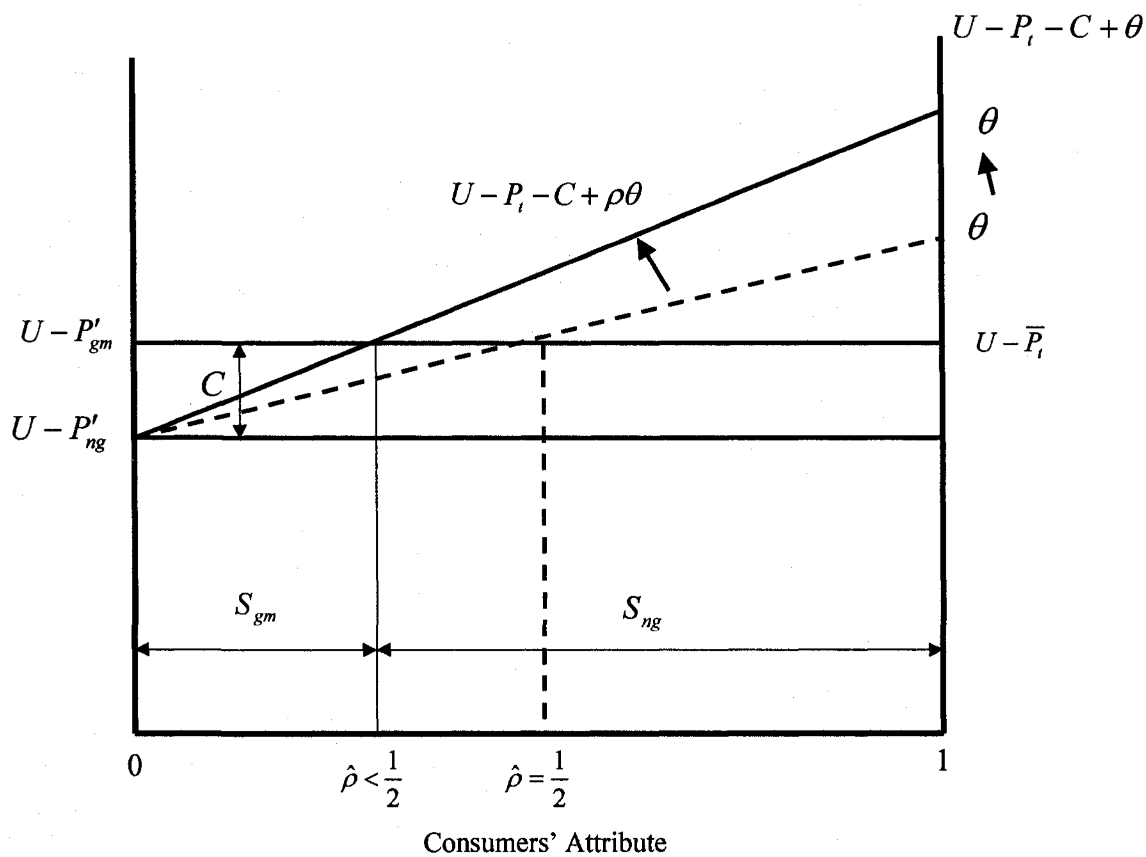
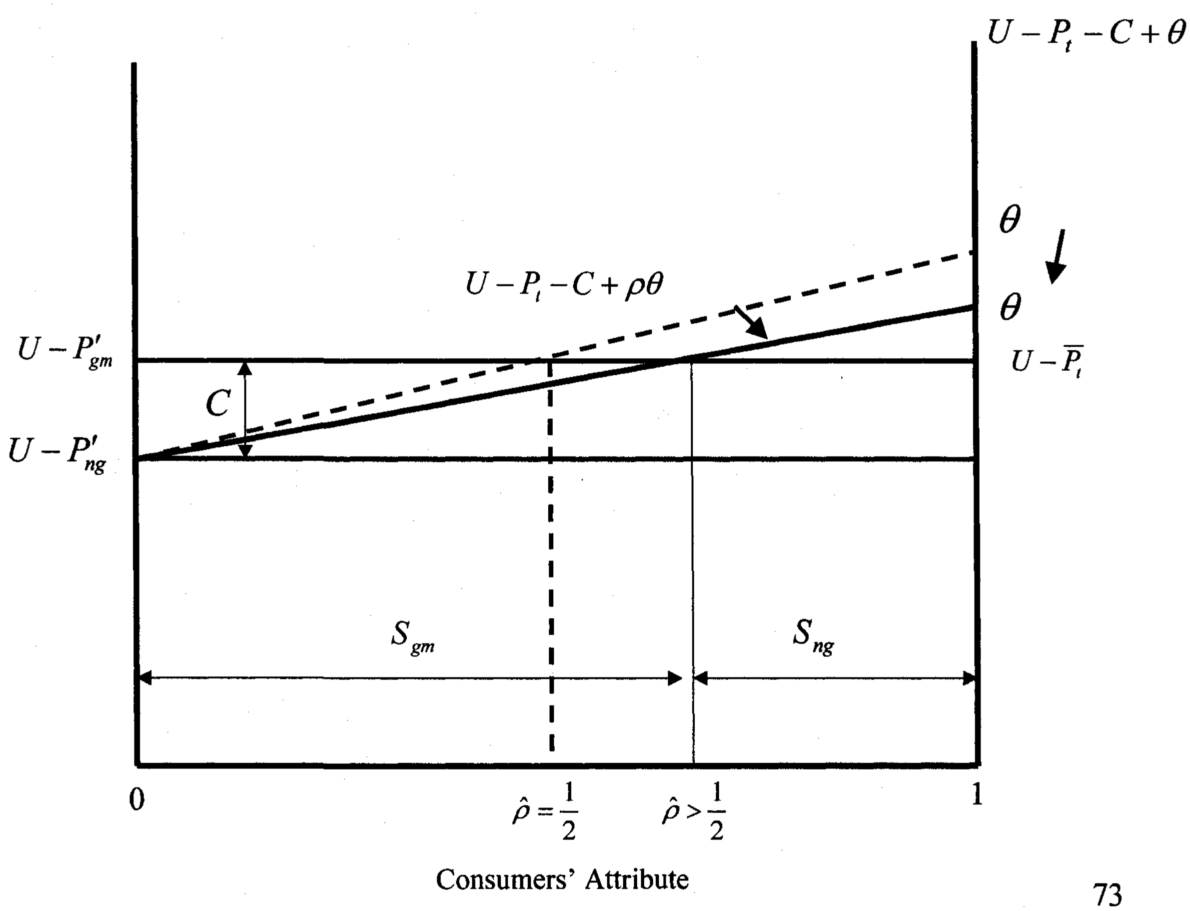


Figure 3 depicts consumption decisions and producers' market share after a decrease in the preference parameter θ from consuming a non-GMO product for any level of ρ. The non-GMO producers' utility U_{ng} rotates downward and intersects with the horizontal GMO producers' utility U_{gm} to obtain the indifference level $\hat{\rho} > \frac{1}{2}$, which reduces the share of the non-GMO product in total consumption. Since non-GMO producers keep the same unit profit margin as under the no labeling regime, and after labeling they lose market share compared with no labeling, therefore, labeling will make non-GMO producers worse off. In this case, it would be optimal for non-GMO producers not to provide the labeling.

Figure 3 Consumption decisions and producers' market share after a decrease in θ.



The above analysis demonstrates that consumers' preference toward non-GMO products or aversion toward GMO products plays a critical role in determining non-GMO producers' labeling decision. The added value of the labeled information is determined by what importance consumers attach to the desired product attributes. The more importance consumers attach to it, the greater the preference factor as a reflection of the value of the labeled information.

Consumers' risk perception

As just shown, consumers' preference factor plays an important role, but there are many factors that underlay consumer preference. First, there are informed and uninformed consumers (Fishman and Hagerty, 2003). Informed consumers can understand the disclosed information and use the information in making a rational consumption decision. Uninformed consumers are not able to do so. Therefore, labeling is of value to informed consumers only.

Second, consumers' attitude toward GMO and non-GMO products is determined by their risk perceptions of the biotechnology. Knowledge and education can impact on consumers' risk perceptions. Consumers tend to avoid products that they are not familiar with, especially when uncertainties are connected. Many consumers reject GMO products simply because they are afraid of any new technology different from the traditional method. When the public has a limited appreciation of new biotechnology, they have low degree of acceptance, and therefore have a higher valuation of non-GMO products (Wolt and Peterson, 2000). Poor and less educated consumers tend to pay less attention to the information they cannot use and do not care (Ho and Vermeer, 2004). This group of consumers is more sensitive to price than information disclosure, therefore any price increase resulting from the disclosed information may force these consumers to consume lower priced products.

Consumers' trust of the government system will impact on shaping consumers' risk perception as well. Public officials and technical experts are viewed as untrustworthy in Europe due to a series of food crisis events, such as 'mad cow disease'. Therefore, consumers there have high valuation of non-GMO products and urge the government to implement the mandatory labeling policy about GMO products.

The Impact of the Size of Segregation and Monitoring Costs

Thusfar, it has been assumed that non-GMO producers do not increase the market price beyond the increase needed to cover the costs of labeling and segregation. However, the size of the labeling costs does affect the consumption and market share of GMO and non-GMO products. The greater are the labeling costs, the greater is the price increase of the non-GMO product relative to the price of the product prior to labeling, and the lower is the utility associated with consumption of the labeled non-GMO products. There are many factors that can affect the size of segregation, monitoring and identity preservation costs. An important determinant of these costs will be the tolerance levels that governments set with their laws, or consumers set with their preferences. The stricter is the tolerance level, the higher will be the segregation and monitoring costs.

Figure 4 and Figure 5 depict how the extent of labeling and the segregation costs affect non-GMO producers' market share.

Figure 4 Consumption decisions and producers' market share after a significant increase in the marketing and segregation costs

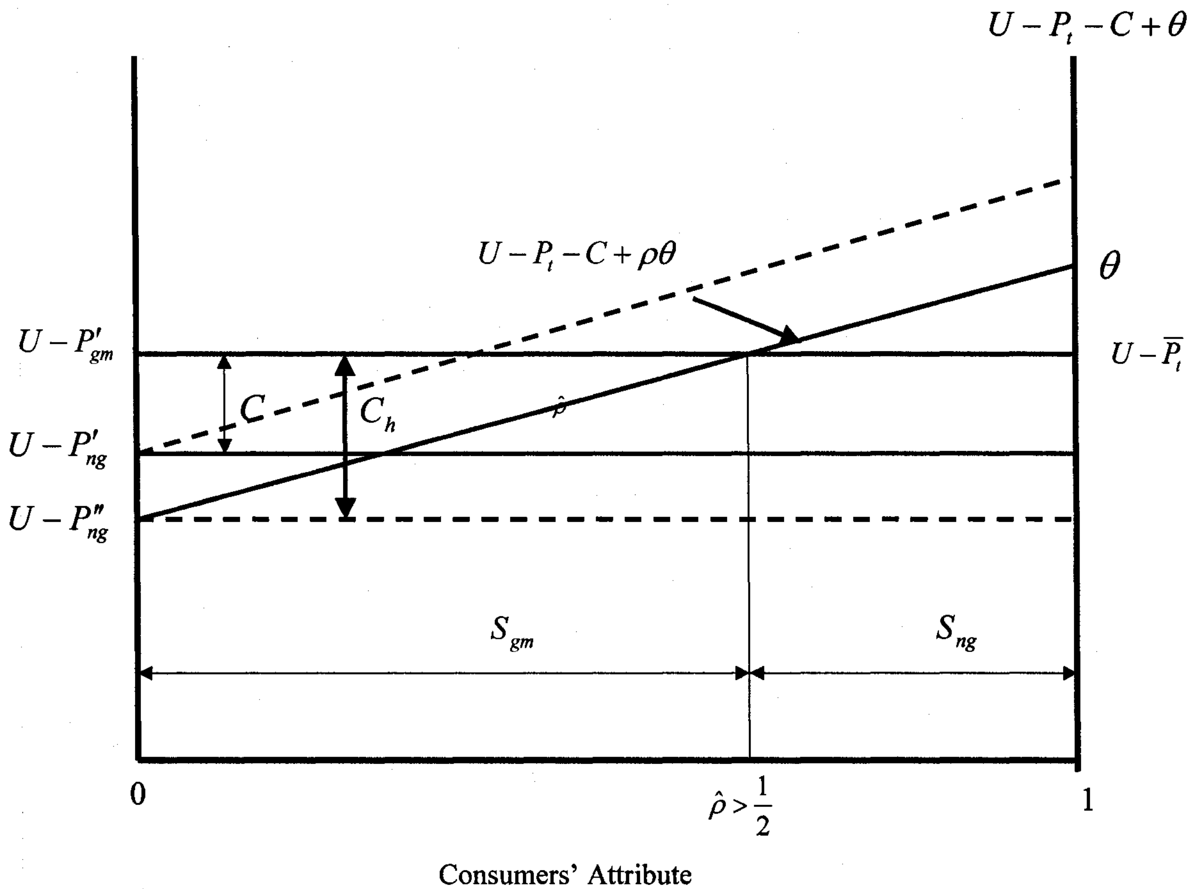
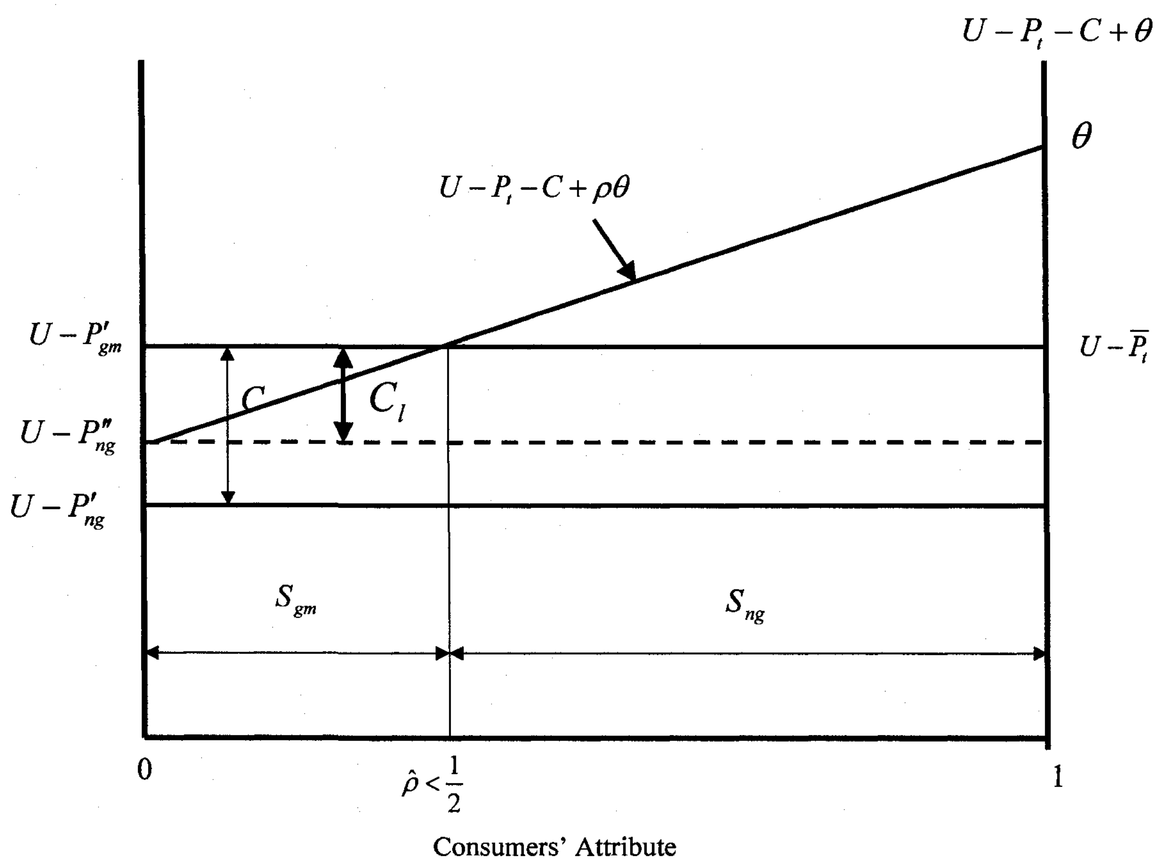


Figure 4 depicts a significant increase in the labeling costs, rising from C to C_h . In this figure, the utility associated with the non-GMO product $U_{ng} = U - P'_{ng} - C + \rho\theta$ becomes the upward sloping utility line $U_{ng} = U - P''_{ng} - C_h + \rho\theta$, which intersects with GMO producers' horizontal continuous curve U_{gm} and determines the indifference level $\hat{p}$. Clearly, the consumption share of non-GMO products is smaller than the last scenario. This suggests that the extent of the labeling costs can affect the market share of non-GMO producers. The greater the labeling costs, the smaller the non-GMO producers' market share. Therefore, the higher labeling costs are, the smaller the market share, and if labeling costs are too high, non-GMO producers' share could drop to zero.

The discussion in Figure 4 can be extended to the scenario of varied unit profit margin for non-GMO producers. In Figure 4, the higher labeling cost C_h can be written as $C_h = C + \partial$, where ∂ is a further increase above *C*. Suppose non-GMO producers attempt to make a larger unit profit margin through labeling, such that the new price for the non-GMO product is written as $P''_{ng} = C + \delta$, where δ is the additional unit profit. The two specifications are very similar to each other. Therefore, as with the previous result in Figure 4, a higher unit profit margin will cause non-GMO producers to lose market share after labeling. Yet, whether non-GMO producers gain or lose profits will be determined together by the increased unit profit margin and reduced market share. This scenario applies when at least some consumers are willing to pay a premium for the labeled information.

It must be noted here that, the previous analysis has only considered various scenarios individually. For example, Figure 4 only focuses on the increase in labeling costs without considering any other change. In the real world, however, many factors can happen together to have impact on the market. For example, if we combine Figure 2 and Figure 4, the higher price of non-GMO products would cause consumers to lose utility which has been shown, while a higher level of preference for non-GMO products will cause an increase in θ, and the result could be that non-GMO producers still gain more market share compared with the "no labeling" system but enjoy a higher unit profit margin as well. Figure 5 depicts a moderate increase in the labeling costs.

Figure 5 Consumption decisions and producers' market share after a small increase in the marketing and segregation costs

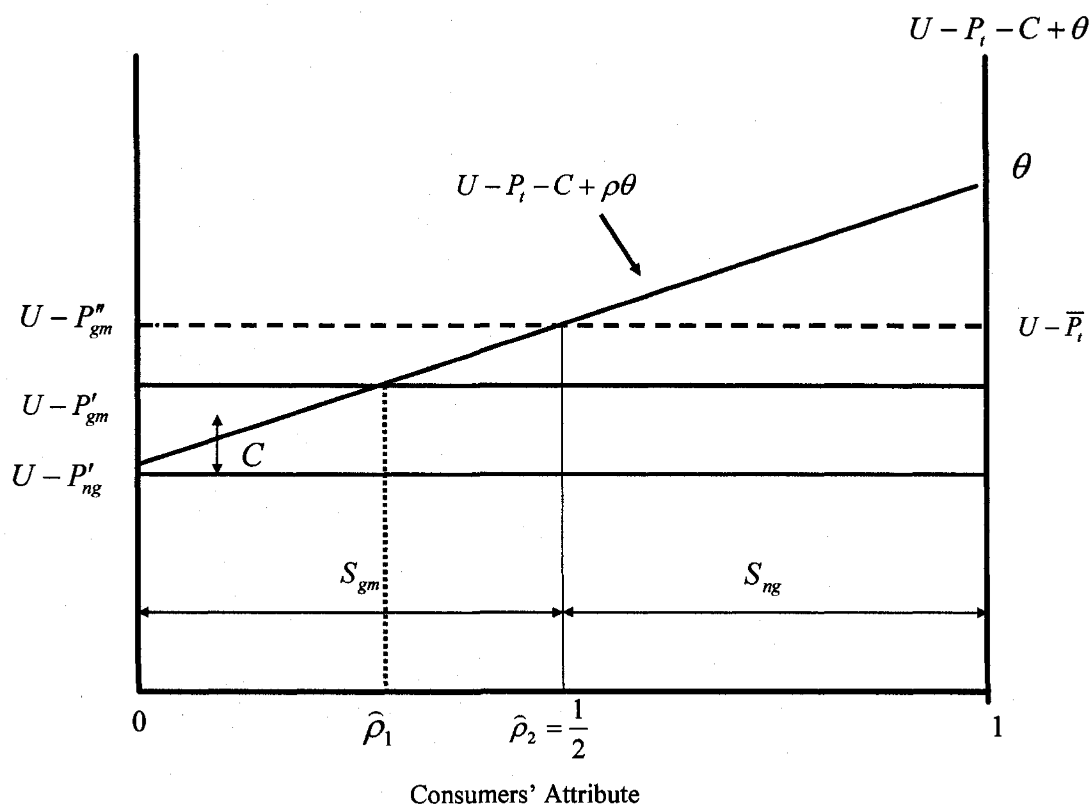


In Figure 5, the increase in the labeling cost is relatively low, lower than the above assumed C. It can be noted that the indifference level moves leftward, $\hat{\rho} < \frac{1}{2}$. Consumers located to the right of the indifference level consume non-GMO products, and are greater than those located to the left side of the indifference level, which means non-GMO producers gain a larger market share in this case. More specifically, using the earlier result that, if $\hat{\rho} = \frac{C}{\theta} = \frac{1}{2}$, or if $C = \frac{\theta}{2}$, then non-GMO producers' market share will not change before or after labeling. If $C > \frac{\theta}{2}$, then non-GMO producers will lose market share by labeling. If $C < \frac{\theta}{2}$, then non-GMO producers will gain market share by labeling. Based on this, it is optimal for non-GMO producers to label the products only if $C < \frac{\theta}{2}$, which is shown in Figure 5.

(4) GMO Producers' Response to Changes in Non-GMO Producers' Market Share

The previous section assumes that both GMO and non-GMO producers do not change their unit profit margin with labeling, and the results show that consumers' indifference level affects both producers' market share. If $\hat{\rho} < \frac{1}{2}$ and given the unit profit margin unchanged as prior to the labeling, then non-GMO producers who label will gain market share while GMO producers will lose market share and profit. If GMO producers want to win back the lost market share and reduced product, then they could respond by using the production cost savings from the adoption of GMO technology to lower the market price to be price competitive in the market. In this case, then both GMO and non-GMO producers' market share will be affected. How their market share will change is determined by the size of the GMO production cost savings. Figure 6 depicts how a change in the GMO product price affects both producers' market share. If GMO producers lower their product price from P'_{gm} to P''_{gm} , the horizontal GMO product consumption utility line will shift upward and the GMO producers' utility will be the dashed horizontal line, and the intersection with the upward sloping non-GMO utility line will shift from $\hat{\rho}_1$ to $\hat{\rho}_2$. Market share increases for the GMO producers. Also, suppose that price reduction is sufficient so that $\hat{\rho}_2 = \frac{1}{2}$. That is, GMO producers have the same market share as prior to labeling.

Figure 6 Producers' market share after a reduction in the GM product price, $\hat{\rho} = \frac{1}{2}$.



As before, GMO and non-GMO producers' profit functions before labeling are given by the following:

$$\pi_{gm} = (P_{gm} - C_{gm}) * Q_{gm}$$

$$\pi_{ng} = (P_{ng} - C_{ng}) * Q_{ng} .$$

After the price reduction in the GMO product and non-GMO labeling, the profit functions become:

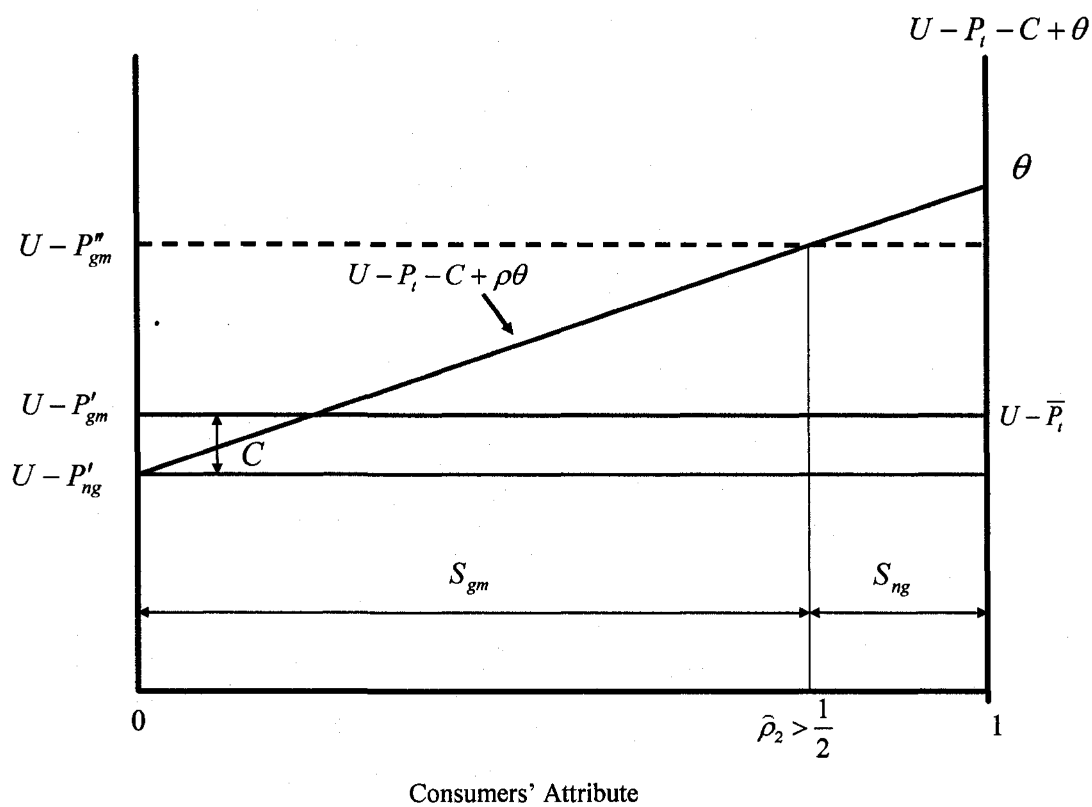
$$\pi_{gm} = (P''_{gm} - C_{gm}) * Q_{gm}$$

$$\pi_{ng} = (P'_{ng} - C_{ng} - C) * Q_{ng}$$

Non-GMO producers have the same unit profit margin and market share as prior to labeling. GMO producers have the same market share but a reduced unit profit margin, since the price they receive is lower. Therefore, GMO producers still suffer an overall profit loss after the product price reduction. This result suggests that when the production cost saving from the GMO technology is moderate, even if GMO producers can lower their market price sufficiently to gain back market share lost due to non-GMO labeling, they are still made worse off. In this case, whether it is worthwhile for GMO producers to respond by lowering price is determined by comparing the profit loss, due to non-GMO labeling, before and after the price reduction.

The next section examines how the market share will change if GMO producers can realize a significant price reduction resulting from the application of GMO technology. Figure 7 shows the situation after a significant price reduction in GMO products that is sufficient so that GMO producers enjoy a larger market share than non-GMO producers. Non-GMO producers now have smaller market share than prior to labeling and thus suffer an overall profit loss. GMO producers have responded by lowering the price to shift the indifference level to $\hat{\rho} > \frac{1}{2}$, giving them more market share than prior to labeling. However, whether GMO producers make the same or more profits is determined by the relationship between the lowered unit profit margin and the increased market share, i.e., whether $\pi''_{gm} = (P''_{gm} - C_{gm}) * Q''_{gm} > \pi_{gm} = (P_{gm} - C_{gm}) * Q_{gm}$. In this scenario, non-GMO producers are made worse off by labeling when GMO producers respond by significantly lowering the price.

Figure 7 Producers' market share after a significant reduction in GMO product price.



One thing is clear from these various scenarios, that the realized profit gain or loss of non-GMO producers is dependent on the level of consumers' preference toward the non-GMO product ρ, the valuation factor θ, and the market price of the GMO and non-GMO products. This analysis suggests that under a voluntary labeling system, it would be optimal for non-GMO producers to label the absence of "GMOs" if consumers in the market have a high level of preference toward non-GMO products and are not very sensitive to product price. If consumers are neutral toward GMO technology, then product price would be a crucial factor to influence their consumption decision. In this case, it would depend on the extent of the production cost savings GMO producers obtain from the GMO technology adoption. If the cost saving is significant, then GMO producers can transform the cost saving into competitive power and cause non-GMO producers to lose market share and make non-GMO producers worse off by labeling. Similarly, if consumers have a low level of aversion toward GMO technology, it would not be optimal for non-GMO producers to pursue a labeling strategy as labeling would not likely bring them benefits.

4.5 Summary

This chapter analyses non-GMO producers' negative labeling decision under a voluntary labeling regime. This analysis employs the framework developed by Giannakas and Fulton (2002), Kirchhoff and Zago (2001) and Rousu *et al.* (2003). The first step was to consider the case of no labeling, in which GMO and non-GMO products are marketed together and sold at the same price. Since GMO producers have lower input costs, they enjoy higher profits compared with non-GMO producers.

However, if the majority of consumers are GMO-averse, and since the consumers cannot differentiate non-GMO products from GMO varieties, producers will experience lower demand for both products. Eventually this will impede the future development of the industry.

Next is a consideration of the case of a voluntary labeling regime. In this case, GMO and non-GMO products are differentiated and marketed separately. Under a voluntary labeling system, non-GMO producers make the labeling decision based on whether they can earn the same or more profits after labeling. Unit profit margin and market share together contribute to the producers' profits. Regarding unit profit margin, two scenarios are discussed, a fixed unit profit margin and a varied unit profit margin. If non-GMO producers do not make a larger unit profit margin, then the purpose of the labeling is to pursue the same or more market share. The size of the labeling costs and how consumers perceive GMO and non-GMO products will affect the GMO and non-GMO producers' market share. If non-GMO producers make a higher unit profit margin through labeling, given consumers' preference parameter toward non-GMO products, their market share will be reduced. In this case they have to evaluate whether they earn more profits or lose profits after labeling. In addition, GMO producers' response to labeling will affect non-GMO producers' profits as well. GMO producers could respond by using the input cost savings from the adoption of GMO technology to a lower market price to gain more market share. The size of the cost savings is critical in determining non-GMO producers' market share. If the cost savings can be perfectly transmitted through the whole supply chain, then the greater the cost savings for GMO producers, the larger is the reduction of market share and profits for non-GMO producers.

Chapter 5: Conclusions

5.1 Summary

GMO technology has had a variety of applications in agriculture, to render crops resistant to herbicides and insect pests, increase growth rates in animals, and impart positive end use attributes to both crop and animal products. This thesis has examined the labeling issue regarding genetically modified organisms (GMOs) in agriculture. Many studies have indicated that farmers benefit from this technology, because the application of GMOs can help reduce the use of chemicals and insecticides, thereby reducing input costs and improving yields. Because GMO technology has not yet appeared in products with consumer-oriented attributes, consumers do not benefit directly, and it is clear that consumers hold different opinions toward GMO-based products, which often result from their different cultural, ethical and economic backgrounds. In general, consumers in developed countries are more concerned about GMO-based products and have a stronger demand for labeling, while consumers in developing countries are more price sensitive, so whether products are GMO-based or not is less of a concern. Many countries such as those in the EU, Japan, the US and Canada have implemented labeling policies. Generally, labeling is mandatory when there is a demonstrable health risk associated with a GMO product. However, countries' policies vary when a GMO product is judged to be substantially equivalent to the corresponding non-GMO product. Producing countries such as the US and Canada have implemented voluntary labeling policies, but consuming countries such as the EU's member countries and Japan have adopted a mandatory labeling policy.

Consumers' "Right to Know," "Substantial Equivalence" and the "Precautionary Principle" are the main rationales behind governments' design of GMO labeling policies, and governments adopt a particular labeling policy based on a cost-benefit analysis, which is not always the case though, because of the political implications. The benefits are obvious, because labeling can help remedy the asymmetric information gap between consumers and producers. At the same time, labeling does add costs, which include segregation, monitoring and IP costs. Although economists have divergent viewpoints on the labeling policies currently available in the market, most agree that a mandatory labeling policy is optimal in markets with a majority of GMO-averse consumers and few GMO producers; and that a voluntary labeling policy is optimal in markets with many GMO producers and price-oriented consumers.

Under a voluntary labeling regime, negative labeling of non-GMO products is considered to be a better choice than positive labeling of GMO products, and is at the heart of this thesis, which attempts to explore when non-GMO producers should pursue a labeling strategy. The theoretical framework used by Giannakas and Fulton (2000), Kirchhoff and Zago (2001) and Rousu *et al* (2003) has been employed for this purpose. Basically, under a no labeling policy, GMO and non-GMO products are marketed together and sold at the same price. Consumers cannot distinguish GMO products from the non-GMO varieties and can only randomly select products. GMO and non-GMO producers evenly split the market. Because GMO producers have lower input costs, they enjoy higher profits than non-GMO producers. However, if a majority of consumers in the market are GMO-averse, and cannot differentiate non-GMO products from their counterparts, demand for both products will be lower. Eventually this will disrupt the market development of the entire industry.

In the case of voluntary labeling, non-GMO producers can choose to label, in order to differentiate their products from GMO varieties. Whether non-GMO producers decide to label is subject to a cost-benefit evaluation. Compared to no labeling, two scenarios are analysed, i.e., fixed unit profit margin and variable unit profit margin. Non-GMO producers make the labeling decision based on whether they can earn the same or more profits by labeling. The unit profit margin and market share together contribute to the producers' profitability, and the size of labeling costs and consumer's perceptions of GMO products affects the GMO and non-GMO producers' market share. The analysis suggests that, under a voluntary labeling system, it is optimal for non-GMO producers to label the absence of "GMOs" if consumers strongly favour non-GMO products and are not very price sensitive. If consumers are neutral toward GMO technology, then price is the crucial factor influencing their consumption decision. In this case, the labeling outcome depends on the extent of the production cost savings GMO producers obtain from adopting GM technology. If this cost savings is significant, then GMO producers can lower their price, causing non-GMO producers to lose market share, making non-GMO producers worse off by labeling. Similarly, if consumers have a low level of aversion toward GMO technology, it would not be optimal for non-GMO producers to pursue a labeling strategy, because labeling would not bring them benefits.

5.2 Limitations of the Framework and Future Suggestions

The framework discussed in this thesis has provided a theoretical perspective for governments that are contemplating the adoption of a voluntary approach to labeling GMO food products, and has discussed other related issues. There are, however, some limitations with the framework that future research should explore. One limitation derives from the model's simple and limited assumptions. A fixed unit profit margin was assumed in the discussion, for example. In future analyses, this assumption can be lifted to better reflect reality. Also, in the framework, only GMO and non-GMO products are assumed, and consumers can only make a decision between the two and have no third option. However, when consumers have high aversion toward GMO products and have little trust in the labeling system, they tend to switch to substitutes or walk away from the products that may have involved the use of GMOs. The existence of substitute can greatly affect producers' market share and thereby producers' labeling decision. Consumers' willing to pay for non-GMO products is also an important aspect to examine in the future research. The extent of the premium that consumers are willing to pay for non-GMO products can have an impact on the incentive that non-GMO producers have to provide the labeling.

An important extension of this study would be to develop the model empirically to assess the effects of a voluntary labeling policy on producer choice in Canada. Currently, there is little data available in Canada to empirically model the producers' labeling strategy, therefore, it would be worthwhile to conduct a number of surveys to collect data, such as the sales of GMO and non-GMO products, the sales of labeled non-GMO and unlabeled non-GMO products, and the sales of competing substitutes. The surveys can start from super markets in a large city, or a franchise grocery store across major cities before aggregating to the national level. It could be expected that household demographic (urban versus rural) and socioeconomic variables (education, income) would affect consumers' consumption decisions and thereby have an impact on producers' labeling decisions eventually.

Notwithstanding these limitations, the economic analysis in this thesis from the producers' perspective has provided certain theoretical insights to facilitate Canadian regulators to determine whether voluntary labeling is the best tool to implement the government's policy initiative, and whether the approach is in the best interests of both producers and consumers, or just one side.

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