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PURITY STANDARDS IN THE OLIGOPOLISTIC FOOD INDUSTRY

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LIST OF ABBREVIATIONS

AP: Adventitious Presence

BSE: Bovine Spongiform Encephalopathy

CPB: Cartagena Protocol on Biosafety

EEC: European Economic Community

EU: European Union

GM: Genetically Modified

GMOs: Genetically Modified Organisms

LMO: Living Modified Organisms

UK: United Kingdom

US: United States

WTO: World Trade Organization

ABSTRACT

Recently, in the food industry, Genetically Modified (GM) food and its related topics have been heavily addressed by many studies. Among the increasingly raised topics are whether or not to accept GM foods, what are the best GM allowance or Purity thresholds, and how does this GM allowance affect the market outcome: i.e. prices and quantities, as well as consumer and producer welfare. These represent some of the economic policy issues for many countries within the European Union and elsewhere.

This research presents a model of heterogeneous consumer preferences and imperfectly competitive suppliers as a helpful tool toward analyzing the market and welfare effects of adventitious presence (AP) thresholds in non-GM foods. While several studies (Giannakas and Fulton, 2002; Fulton and Giannakas, 2004, Lapan and Moschini, 2006/ 2007, Giannakas and Yiannaka, 2008; Giannakas and Kalaitzandonakes, 2005) refer to the GM issue, few of them have addressed the issue of regulatory standards in oligopolistic suppliers, and to our knowledge, none have address vertical oligopoly. Hence, in this research, we consider the economic implications of AP thresholds of GM foods under various market structures of oligopoly and vertical oligopoly, where both processors and retailers have market power.

By comparing the equilibrium quantities and prices, as well as consumers' and producers' welfare before and after changing the purity standards, we determine the market and welfare effects of different purity thresholds. Our analysis indicates that a change in purity thresholds creates winners and losers among consumers and producers of both GM and non-GM products. Also, examined in this research is how, considering different model parameter scenarios, consumers and producers are affected differently by these purity thresholds. We establish parameters with respect to different levels of market power and simulate them with various values attributed to the parameters. What determines winners and losers is the degree to which the purity standards affect the production cost and consumers' preferences.

The research is considered to be useful for policy makers, academics, consumer organizations, firms and farmers of GM and non-GM products, by providing insights on the market and welfare impacts of the AP thresholds

CHAPTER 1

INTRODUCTION

In recent years many countries have adapted Labeling Food Policies regarding Genetically Modified (GM) products but the applied regimes differ widely across the world (Gruere, 2004). The great difference lies between the European countries (EU) which have applied a mandatory food labeling regime and the United States (US) which has chosen not to impose such requirements and implement a voluntary food labeling policy. Accepting the need for a labeling policy still leaves open the problem of the adventitious presence (AP) thresholds or tolerance level which represents the maximum level of impurity in non-GM food. The problem of the appropriate purity standards norm has been a topic of discussion since the 1980s and yet it remains a core issue (Giannakas and Kalaitzandonakes, 2005). The EU countries adapted the most stringent policy requiring mandatory labeling for all foods produced from GM ingredients regardless of whether or not the final product contains any sign of GM material. Meanwhile, to avoid carrying a GM label the EU countries set the AP thresholds to 0,9% which, to date, is considered the highest GM allowance. Japan requires labeling for food products that contain more than 5% GM material (top three ingredients), followed by South Korea which requires labeling at the level of 3% AP thresholds (top five ingredients) (Gruere,2003; Lapan and Moschini, 2006).

Even though the differences in these AP thresholds look insignificant, they affect the production cost and segregation cost of non-GM products; while the AP thresholds increase (decrease) the non-GM production cost decreases (increases) (Kalaitzandonakes and Magnier, 2004). Additionally, consumers´ evaluation of both GM and non-GM foods are affected by a change in AP thresholds (Noussair et al., 2004; Giannakas and Kalaitzandonakes, 2005). As a result, both consumer and producer welfare are affected by the change in AP thresholds, hence considering the effect that the food industry has in the entire economy, undoubtedly AP thresholds play a significant role for policy makers. Thus, from an economic perspective the impacts of AP thresholds are associated with the changes in consumer and producer welfare (Fulton and Giannakas, 2004; Lapan and Moschini, 2005/ 2006; Giannakas and Kalaitzandonakes, 2005).

Giannakas and Kalaitzandonakes (2005) have developed a methodological framework to determine the market and welfare effects of purity standards in food labeling laws. We follow the same approach as Giannakas and Kalaitzandonakes (2005) but what makes the difference is the fact that our analysis explicitly accounts for an extended food chain. A framework model is developed to determine the market and welfare effects of purity standards in a two and three stage supply chain inducing additional market power in the model. Furthermore, a simulation analysis is conducted in order to present a clear picture of the impacts that the purity standards have in the market and on welfare.

Lapan and Moschini (2007) are dealing with the purity standards issue by assuming a perfect competitive market for the GM and non-GM products. A key difference between our study and that conducted by Lapan and Moschini (2007), lies on the specific market structure. In this study, the market power is a basic element of the analysis while in Lapan and Moschini (2007), the market power is not taken into consideration.

Sexton and Zhang (2001) determined that the market power itself has an impact on equilibrium prices and quantities, consumer, retailer, processor and farmer surplus. They have analyzed various sub cases depending on the way market power is exercised within the supply chain assuming a homogeneous product traded in the market. Sexton and Zhang (2001) have developed a simple model accounting for different market structures represented as specific scenarios. Their study considers only one product while we explicitly account for two vertically differentiated products as GM and non-GM. However, we support Sexton and Zhang (2001) results which state that the market power exercised within the supply chain affects the welfare distribution.

The aim of this thesis is to determine the effects of purity standards of non-GM products on suppliers´ and consumers´ welfare. Particularly, our analysis accounts for the allowance of GM material in non-GM foods. By deriving the equilibrium quantities and prices, comparing and contrasting them, before and after changing the AP thresholds, with and without market power, we show analytically the market and welfare effects of AP thresholds. The starting point is a benchmark case of 0% AP thresholds implied under a perfect competitive market. We proceed by determining the effects of increased AP thresholds, by firstly introducing an oligopoly, continuing with the monopoly and finally concluding with a vertical market power within the supply chain.

Specifically, in our model the following key components are present in order to shed light in understanding the model. They include:

a. heterogeneous consumers with preferences toward GM and non-GM foods
b. heterogeneous production costs of both GM and non-GM products.
c. market power exercised in the supply chain for both GM and non-GM food

In addition, this study emphasizes an extension of the existing literature on the purity standards issue. As different purity standards have been shown to have significant effects in the market equilibrium as well as on consumer and producer welfare, it provides useful insights for all the involved and interested European groups (consumers, farmers, processors, retailers, seed companies, policy designers) (Giannakas and Fulton, 2002; Fulton and Giannakas, 2004; Kalaitzandonakes and Magnier, 2004; Lusk et al., 2004; Lapan and Moschini, 2004/ 2005/ 2007; Giannakas and Kalaitzandonakes, 2005).

The rest of the thesis is organized as follows:

Chapter (2) presents background information referring to the evolution of GM products, their regulations around the world, and farmers´ and consumers´ behaviors towards GM items. Chapter 3 presents the equilibrium prices and quantities in an oligopoly and vertical oligopoly as well as consumer, retailer and wholesaler characteristics in the abovementioned market structures. A simulation analysis is conducted in Chapter 4 displaying both analytically and graphically, all the possible scenarios. These include: Perfect Competition, Oligopoly, Monopoly and Vertical Oligopoly before and after changing Purity standards. Chapter (5) involves the discussions, concluding remarks and suggestions.

CHAPTER 2

REGULATION AND ACCEPTANCE OF GM PRODUCTS

Before analyzing the market and welfare effects of purity standards it is important to give general information on the farmers' behavior towards GM foods, consumers' concerns about these products and food labeling policies across the world.

2.1 Farmers´ Behavior towards GM Foods

What makes an innovation important to adapt to, for example a new technological development, is that it offers benefits over and above what is currently available. These kinds of benefits vary in their nature and category; they may be perceived as lower cost technology, more functionality, or more enhanced quality. Agricultural biotechnology is claimed to offer a range of benefits such as higher productivity, lower pesticide costs for producers and less environmental pollution, at least in the minds of developers. Europe's first GM product was introduced in February, 1996 by J. Sainsbury and Safeway Stores in the United Kingdom (UK). Later on, many agronomic improvements occurred in the crop fields (soybeans, cotton, maize and canola). In 2005, GM crops, were grown in twenty one countries by an estimated 8.5 million farmers on a total acreage of 90 million hectares (James, 2005) reaching 114 million hectares in 2007 (James, 2007). Farmers have adapted the new technology due to the increase in efficiency and definitely because of the increased benefits they achieve by using it. Table 2.l poses the change occurred in the area used for GM production in the world from 1996 to 2005. As is depicted in Table 2.1, a drastic increase occurred in the GM product area during a 9- year period from 1996 – 2005. Furthermore, Table 2.1 also depicts that throughout the years 1996 – 2005, more and more countries have adapted the GM technology reflecting the increased level of adoption.

Table2.1: The Global Area under GM grower countries

Years	Hectares(million)	Countries
1996	1.7	US, China, Canada, Argentina, Australia and Mexico
1997	11	US, China, Canada, Argentina, Australia and Mexico
1998	27.8	US, China, Argentina, Canada, Australia, Mexico, Spain, France and South Africa
1999	39.9	US, Argentina, Canada, China, Australia, South Africa, Spain, France, Portugal, Romania and Ukraine.
2000	44.2	US, Argentina, Canada, China, South Africa, Australia, Romania, Mexico, Bulgaria, Spain, Germany, France, Portugal, Spain, France, Portugal, Ukraine and Uruguay.
2001	52.6	US, Argentina, Canada, China, South Africa, Australia, Mexico, Bulgaria, Uruguay, Romania, Spain, Indonesia and Germany
2002	58.7	US, Argentina, Canada, China, South Africa, Australia, India, Colombia, Honduras, Mexico, Bulgaria, Uruguay, Romania, Spain, Indonesia and Germany
2003	67.7	US, Argentina, Canada, Brazil, China, South Africa, Australia, India, Colombia, Honduras, Mexico, Bulgaria, Uruguay, Romania, Spain, Indonesia, Germany and Philippines
2004	81	US, Argentina, Canada, Brazil, China, South Africa, Australia, India, Colombia, Honduras, Mexico, Paraguay, Uruguay, Romania, Spain, Germany and Philippines
2005	90	US, Argentina, Canada, Brazil, China, South Africa, Australia, India, Colombia, Honduras, Mexico, Paraguay, Uruguay, Romania, Spain, Germany, Philippines, Iran, Portugal, France and Czech Republic

Sources: Information for all years has been adopted from James for that respective year.

In addition, it is important to mention that large scales of adoption have been developed only for a few kinds of GM crops. The production of animal fed crops or non food use crops has increased while the other crops, especially the food use crops, have incurred a slight increase. The reason is that many countries (where the initiators are the EU countries) are concerned about the `hazards´ of GM foods especially where their destination is for food use. However, there has been a widespread acceptance and support from the scientific community towards biotechnology.

2.2 Consumers' Behavior Toward GM Foods

While the adoption of GM foods is rapidly increasing from the producers´ point of view, consumers generally and European consumers particularly, have been opposing the development of GM products, especially for food use. Consumer opposition to GM foods is mainly expressed in opinion surveys. Gaskell (2000) reports the results of a survey conducted in 1999 with a total sample of 16082 respondents about consumer behavior towards GM foods (Sheldon 2004). Although Europeans are more and more optimistic about biotechnology, their overall feeling on GM food is that it should not be encouraged. Several food crises such as the BSE (also known as the Mad Cow Disease) incident first occurred in the UK and has recently spread in the EU. Toxic chemical contamination of poultry from various sources which occurred in Belgium, have concerned Europeans about the food they consume. Moreover, consumers are aware of health and environmental risks, or raise the issue of the ethical concern problem, but they are not aware of the benefits GM foods provide (i.e., consumers are not familiar with the reduction of pesticides in agricultural products and the improvement of the nutritional content)

More specifically, philosopher Paul Thompson defines four types of ethical concerns towards GM technology (Sheldon, 2004):

1. Various cultural, religious and physical traditions have long treated the living organisms as having ``essences`` which must be respected.
2. Humans have consistently treated species boundaries as reflecting a ``natural order`` and biotechnology is thought to threaten that order.
3. Many religious traditions prohibit either trans-species production or their consumption.
4. Individuals may simply have an ``emotional repugnance`` to genetically modified food.

Referring to the food safety issue, there are some concerns that the transfer between different species might result in allergenic risk to foods, or that human pathogens will become resistant to antibiotics.

Regarding environmental concerns, there is also an expectation that GM crops are harmful to the environment by harming non target species, and contaminating the non-GM crops. Moreover, the crops that are modified to be resistant to certain herbicides may have the same resistance on weedy relatives (Sheldon, 2004).

Recent researches (Huffman et al., 2003) have claimed that consumers are highly biased toward Non-GM products. When asked how much they were willing to pay for GM labeled food, it was found that many of them showed less willingness to pay for GM food.

Overall, European consumers regard gene technology in agriculture and food products with skepticism, but this should not be considered as a blanket refusal for GM products. It is evident that accurate information on GMOs is the key for raising consumer acceptance for such products. Furthermore, contrary to the widespread opinion they may have considerable chances in the EU market.

2.3 National Food Labeling System in the World

Even though the methods of measuring the food safety are the same around the world (Kalaitzandonakes et al., 2006), what is obvious is the fact that there is heterogeneity in the food policies that different countries have adapted. More than 40 countries have adapted food policies but they differ greatly in their characteristics and in their degree of implementation (Phillips and McNeill, 2000; Carter and Gruere, 2003). What they have in common is the fact that all these countries are required to label the product that is derived from GM crops and which is not equivalent to its conventional counterparts. On the other hand, for the products derived from transgenic crops but which are considered equivalent to the conventional counterparts, there is a large diversity in the labeling policies.

Firstly, countries are separated in adapting either voluntary labeling guidelines (the US, Canada, Hong Kong) or mandatory labeling regulations (the EU, Australia, Brazil or China). On the one hand, the voluntary labeling policies just dictate the rules defining whether a product is considered GM or not. In addition, this system does not oblige any food chains to label their GM foods. On the other hand, countries that introduced mandatory labeling regimes (the EU, Japan, South Korea, New Zealand, Australia, and China) do require all food chains to label their GM products.

The EU adapted the most stringent food policy due to ethical, environmental and political reasons setting the purity standards at 0,9%. Since the GM allowance in the non-GM foods is considered to be accidental and unavoidable, these purity standards are often referred to as Adventitious Presence (AP) thresholds. In contrast, the most liberated policy related to GM foods is implemented in the US which applied the highest GM allowance of 5%. The US claims that obligatory regulations violate free trade agreements while the EU position is that free trade is not completely free without informed consent. The purity thresholds for middle countries vary from 1% to 5%. Countries that want to collaborate with the EU-countries must label their GM products and must have a purity threshold similar to theirs.

The same thing can be said for the countries that want to have economic collaboration with the US. They have to adapt a food policy similar to the US food policy. There are countries which have partly adapted a food policy and other countries which have yet to adapt any kind of policy. The reason why these countries are still without regulations is that the introduction of any particular policy may affect their relations with the current and future agricultural importing country. Table 2.2 reflects the differences in food regulations around the world. They differ in terms of coverage, exemptions and applied purity thresholds.

Table 2.2: Characteristics of the national labeling system, February 2007

Countries	Labeling policy	Coverage	Major exemptions	Purity Threshold Level
European Union	Mandatory &national voluntary guidelines	Food, feed, additives, flavorings, products derived from GM, restaurants	Meat and animal products	0,9%
Brazil	Mandatory	Food, feed, products derived from GM, meat and animal products	Virtually none	0.01
China	Mandatory	List, products derived from GM, restaurants	Outside of list	None 0%
Australia-New Zealand	Mandatory & voluntary	All products based on content	Processed products	0.01
Japan	Mandatory & voluntary	List of food items	Processed products	0.05
Indonesia	Mandatory	List of food items	Outside of list	0.05
Russia	Mandatory	All products based on content	Feed	0,9%
Saudi Arabia	Mandatory	List of food items	Outside of list, restaurants	0.01
South Korea	Mandatory & voluntary	List of food items	Processed products	0.03
Taiwan	Mandatory & voluntary	List of food items	Outside of list	0.05
Thailand	Mandatory	List of food items	Outside of list	0.05
Argentina	Voluntary	Not specified- all products based on contents	_	-
South Africa	Voluntary	Not specified- all products based on content	_	-
Philippines	Voluntary	All products based on content	_	0.05
Canada	Voluntary	All products based on content	_	0.05
United States	Voluntary	All products based on content	_	n/a

Source: Carter and Guere (2003a), Cevallos (2006)),Foster and French (2007)

Even though there are significant differences in the food labeling policies around the world, at the international level there have been some harmonization efforts led by:

1. The Codex Alimentarius Commision: This was created in 1963 by the United Nations Food and Agriculture Organization and the World Health Organization. It is a set of international codes and practices, standards, guidelines and recommendations related to food production and food labeling established to protect consumer's health and to ensure a fair international trade.

2. Cartagena Protocol on Biosafety (CPB): This was presented in January 2000, but it was implemented not earlier than September, 2003. This protocol provides rules for the identification of any movement of living modified organisms (LMO) in order to protect biological diversity.

3. The World Trade Organization (WTO): This is an international organization created in 1995 to supervise and liberalize the international trade.

It is important to mention that while international harmonized guidelines relating to the safety approval have been finalized at the Codex Alimentarius, there is no clear consensus on labeling regulations for GM food, and this might result in conflicts between CPB and WTO (Gruere, 2006).

2.4 EU Regulations

The European Union has enforced one of the most stringent food policies regarding importation of GM products, including stock feed (Foster and French, 2007). The EU- countries have set the purity threshold from 1% to 0.9% and this is the lowest allowance of the GM material in a food product. Though the difference is very small, a lot of work and time is necessitated to establish the purity threshold from 1 to 0.9% (which means it was a long and a costly process). The EU regulations' approach is based on the "precautionary principle" and consumers' "right to know" with stringent approval, labeling and traceability standards on any food produced or derived from GM ingredients (Gruere, 2006). While the US and Canada have based their regulations on the principles of equivalence i.e., if there is a consensus among scientists that GM food is substantially equivalent to the non-GM food, then the former is assumed to be safe and there is no need to introduce mandatory labeling (Sheldon and Josling, 2001; Maclaren, 2004).The EU countries seek to be prudent and not to accept the notion of substantial equivalence without overwhelming evidence that it is safe to do so. The labeling process is implemented for every stage of the production process. In other words, a product is labeled as a GM product if the production process includes genetically modified engineering at some level even though the final product does not have any trace of GM material. This requires continuous testing of the products throughout the channel from farmers to consumers. Labeling requirements engage all the food and feed crops unprocessed or processed. Only products like textile or other industrial products (which are not used as food products), or products such as meat, milk or eggs (produced from animals fed with GM feed), are excluded from the labeling requirements.

The EU legislation governing food and feed products derived from GM crops includes:

- Directive 90/219 EEC, introduced in 1990 makes reference to the use of GMOs for protecting human health and the environment.
- Directive 90/220 EEC applied in 1991 refers to the deliberate release of GMOs into the environment.
- Regulation 258/97 entered in force in 14-05-1997 relates to the Novel Foods and novel foods ingredients.
- Regulation 1139/98 requires the labeling of certain foodstuff containing approved GM soybeans and GM corns.
- Regulation 49/2000 introduced mandatory labeling of GM food and GM ingredients at the 1% level.
- Regulation 50/2000 extended the labeling requirements to food ingredients containing GM additives and flavorings
- Directive 2000/13 EC (introduced in March 2000) is related to the labeling, presentation and advertising of foodstuffs.
- Directive 2001/18 EC (introduced in 2002) stresses the deliberate release of GMOs into the environment and repealed the council directive 90/220 EEC.
- Regulation 1829/2003 (entered into force in April 2004) evaluates the potential risk arising from GM foods.
- Regulation 1830/2003 of the European Parliament and the Council (enforced in 20/11/2003) relates to the traceability and labeling of GMOs and the traceability of products as well as food and feed products derived from GMOs foodstuffs.

Opponents of the mandatory labeling regime claim that such a label raises marketing costs, possibly inhibits future developments of GM technology and is unnecessary since the GM products are equivalent to the conventional counterparts (Carter and Gruere, 2003). In response, the supporters argue that GM foods are not equivalent to their conventional counterparts, consumers are the ones to make the decision of what to buy, and biotechnology creates so called credence goods (Sheldon, 2004)

The discussion so far has been referring to evolution, acceptance and regulation of GM foods. Consumer and farmer behavior towards GM products is shown to be different. Farmers support GM production due to the cost savings GM products offer. Despite this farmer support, there continues to be a consumer resistance and opposition to GM foods. Incorporating both consumer and supplier's behaviors in the model is the aim of the next chapter. The next step is the discussion of the framework theory used to determine the market and welfare effects of purity standards. This thesis develops an analytical model for determining the market equilibriums and welfare distribution when the purity standards increase and market power is exercised downstream in the supply chain. We begin by analyzing a benchmark case of 0% AP thresholds and zero market power in the supply chain, and continue with changing the AP thresholds and market power in order to determine the overall effects in the market.

CHAPTER 3

MARKET CHARACTERISTICS IN AN OLIGOPOLISTIC MARKET

In this chapter we set up the model based on consumer and supplier characteristics. Deriving the demanded and supplied output, equilibrium market prices and quantities, consumer, retailer and processor (wholesaler) characteristics are the main objectives of this chapter. Both sides of the market are assumed to be heterogeneous in this model. Consumer preferences depend on the utility enhancement a consumer achieves when consuming one unit of a product, while producer returns depend on production cost. The starting point is the case of zero GM allowance in non-GM food. Two alternative sub cases relating processor and retailer interactions are considered in the model. Both retailers and processors are considered to be price takers in the first sub case, while the second one involves processor oligopoly power and retailer price taking in the processor-retailer interactions.

3.1 Previous Modeling Approaches to the GM Problem

Two basic elements such as vertical product differentiation and vertical market power are considered in building up the model. Both building blocks of the theory and previous approaches about them are presented below.

3.1.1 Vertical Product Differentiation

The consumer premise is that, whereas GM and non-GM products are offered at the same price, they will never choose the GM products. Meanwhile, some consumers are willing to pay some extra money to avoid GM food. So, as in previous studies (such as Giannakas and Fulton, 2002; Lapan and Moschini, 2004/ 2007, Giannakas and Kalaitzandonakes, 2005) we model GM and non-GM products as vertically differentiated. Lapan and Moschini (2004) have provided that the GM product is a weak inferior substitute for the non-GM counterpart. In vertical differentiation, all consumers agree upon the quality ranking of the products from the highest to the lowest. If two vertically differentiated products are offered at the same price, all consumers will buy the high quality good driving the low quality good out of the market. Lower quality products will realize a positive market share only if they are offered at a sufficient price. However, consumers differ in their willingness to pay for a better perceived quality. Some consumers place a high value on quality and will pay a considerable premium to consume a high quality product while some others do not. In other words consumers examine the ratio price- quality and the utility obtained from the offered product, deciding to buy it in case the utility is greater than the price being charged and just refuse to buy it if the opposite is true. On the other hand, horizontally differentiated products are not uniform quality ranked. If two horizontally differentiated products are offered at the same price, the consumer will not agree on what the best quality is, and so both products will be demanded in the market.

3.1.2 Oligopoly and Vertical Oligopoly

Indeed, the market power within a supply chain has impacts on market equilibrium and welfare distribution. Sexton and Zhang (2001) analyzed different market structures and proved that market power itself plays a considerable role in the equilibrium prices and outputs as well as on consumer and producer welfare. Similarly, in our model we consider a channel where two different products are produced from different farmers, procured then by different processors which transfer the final products to independent retailers, and here, the final product is offered to the same consumers. Consumer inverse demand for the retail product is as follows:

$$P_{ri} = a - b * X_{ri} \tag{1}$$

where X_{ri} is the market quantity for both GM and non-GM products, and P_{ri} is the market price for GM and non-GM foods, respectively. In order to focus the analysis on the possible implications of market power in the industry, we assume that both the processor and retailer of GM and non-GM products utilize both fixed-proportions and constant-returns technology in the processing or retailing process.

Throughout the analysis, consumers and farmers are assumed to be price takers. Thus, we derive the implications of two combinations of horizontal and vertical oligopolistic power in the retailing and processing sector, on market equilibriums and distribution of welfare among consumers, retailers and processors.

3.2 Horizontal Oligopoly and Vertical Product Differentiation: The Model

The first case study includes vertical product differentiation and retailing oligopoly power versus the consumer.

3.2.1 The Market Structure

As previously mentioned, the model is based on an oligopolistic market, represented by a few retailers who exercise market power on consumers. We assume that competitive interactions exist between farmers and processors. There is a specific product chain for the two products and the meeting chain is the consumer's side. On the other hand, there are many consumers who are price takers and do not have any power to affect the price. In this chapter, farmers and processors are assumed to be perfect competitors. The representative framework for each product is illustrated in Figure 3.1 below.

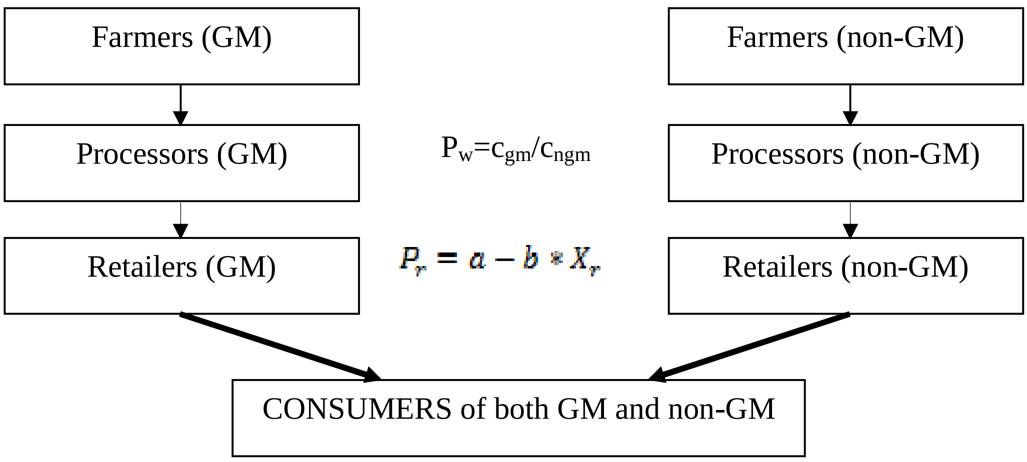

Figure 3.1: Market structure in an Oligopolistic Market

Source: Own calculations

Where ↓ indicates price taking, while ⬇ indicates market power.

To capture the prominent consumer preferences toward GM and non-GM products we follow Lusk et al. (2005); Giannakas and Fulton (2002); Fulton and Giannakas (2004) and Giannakas and Kalaitzandonakes (2005) assuming that GM and non-GM products are vertically differentiated or quality ranked (if offered at the same price the consumer would rather have the non-GM foods). Our analysis accounts for heterogeneous consumer preferences as well as production costs. The GM and non-GM products share the same observable characteristics (e.g. the same appearance) while they differ in the technology used in the production process.

3.2.2 Consumer Characteristics

Firstly, let's assume that consumers spend a specific amount of their income for food. Then, the utility they gain by consuming these foods will be as follows:

$$
\begin{aligned}
&U_{gm} = U - P_{gm} + \lambda\alpha && \textit{if a unit of GM product is consumed} \\
&U_{ngm} = U - P_{ngm} + \mu\alpha && \textit{if a unit of Non Gm product is consumed} \qquad (2) \\
&U_s = U && \textit{if a unit of a substitute product is consumed}
\end{aligned}
$$

where:

- U_{gm} and U_{ngm} are the utilities associated with consuming a unit of GM and non-GM unit, respectively;
- U_s is the utility associated with the consumption of a unit of substitute products neither of which are GM nor non-GM products. Specifically, U_s represents a certain utility level which is considered equal to a basic level of utility. In order to ensure a positive utility associated with the consumption of different products, U_s exceeds the prices of GM and non-GM and is common to all consumers;
- P_{gm} and P_{ngm} are the prices of GM and non-GM products, respectively, while parameters λ and μ capture the utility enhancement from consuming GM and non-GM foods, respectively;
- α captures the heterogeneity in consumer preferences. Its value ranges from 0 to 1 and consumers are assumed to be uniformly distributed at the extremes.
- $U+\lambda\alpha$ and $U+\mu\alpha$ indicate consumer willingness to pay for GM and non-GM products, while $(\mu-\lambda)\,\alpha$ reflects the level of aversion toward GM products of the consumers with attribute α.

3.2.3 Retailers´ Characteristics

This analysis accounts for heterogeneous production costs too. Retailers differ from each other in terms of the benefits they gain by producing a GM or non-GM product. Particularly, they differ in their earnings due to the differences in the total costs of both products introduced in the model as c_{gm} and c_{ngm}. The production and segregation cost that a GM supplier faces is smaller than the one that a non-GM supplier does. Accordingly, their benefits will be different as well. Subsequently, we show the objective function which maximizes benefits for both GM and non-GM suppliers. Retailers' prices, as mentioned earlier, are assumed to be a linear function expressed as P_{ri} = a- b*X_{ri} where i Є {GM, non-GM } and $X_{ri} = f(x_1, x_2..)$. A representative retailer's profit maximization functions can be expressed as follows:

$$\pi_r = P_r * X_r - c_r * X_r \tag{3}$$

Where P_r, X_r and c_r, represent retailer price, quantity and cost, respectively.

In particular, for a GM retailer the profit maximization function is as follows:

$$\pi_{gm} = (a - b * X_{gm}) * X_{gm} - c_{gm} * X_{gm} \tag{4}$$

In order to optimize the profit maximization we take the first order condition (FOC):

$$\pi' gm = (a - b * X_{gm}) - \frac{b * x_{gm} * \Delta X_{gm}}{\Delta x_{gm}} - c_{gm} = 0 \tag{5}$$

$$\boldsymbol{a - b * (1 + \theta_{gm}) * X_{gm} = c_{gm}} \tag{6}$$

Similarly, applying the same derivation for the non-GM suppliers, the resultant function is:

$$\boldsymbol{a - b * (1 + \theta_{ngm}) * X_{ngm} = c_{ngm}} \tag{7}$$

where:

- $\theta_i = \frac{\Delta Q}{\Delta q} * \frac{q}{Q}$; {i=gm, ngm} is the conjectural elasticity capturing in our analysis the market power exercised in the supply chain. It takes on values between 0 (perfect competition) to 1 (monopoly) (Sexton and Zhang, 2001).
- c_{gm} and c_{ngm} are the marginal costs of GM and non-GM products, respectively, faced by the retailers of these products. The retail cost comprises:
    1. The production, processing and marketing costs over all supply chains of GM and non-GM products
    2. The costs of labeling and segregating a product (in our model these costs are being incurred in the non-GM supply chain), and
    3. The market power at previous stages of the supply chain (such as the market power of input sellers, food manufacturers). The greater the costs mentioned above, the greater the retail costs on the suppliers.

3.2.4 Consumers´ Decision and Welfare Before Changing the Purity Thresholds

Consumer purchasing decisions depend on the utility they gain by consuming certain products. The greater the enhancement utility they gain by consuming a specific product, the greater the demand or consumption of that product. It is important to point out that a consumer with an α value equaling zero is indifferent in consuming a unit of substitute, GM or non-GM products. Figure 3.2 shows consumers' decisions and welfare when GM, non-GM and substitute products are available.

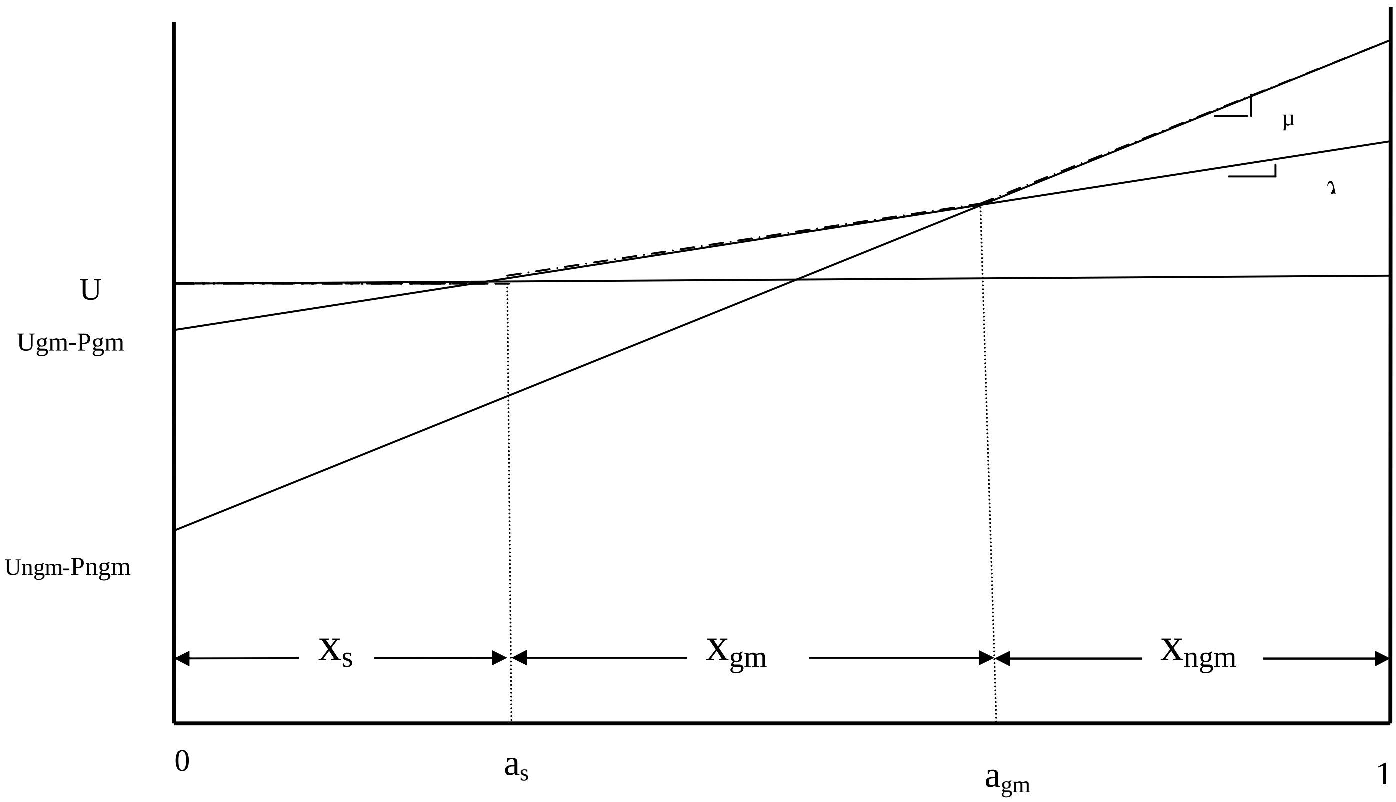

Figure. 3.2: Consumers´ decision before the AP thresholds change

As illustrated in Figure 3.2, the level of the attribute corresponding to the indifferent consumer is determined by the intersection of the two utility curves. In our case, the consumer with the differentiating attribute: α_s: $U_{gm}=U_s \Rightarrow U-P_{gm}+\lambda\alpha=U \Rightarrow \alpha_s = P_{gm}/\lambda$ is indifferent in consuming either a GM product or the substitute one. On the other hand, the consumer with the differentiating attributes: α_{gm}: $U_{gm}=U_{ngm} \Rightarrow U-P_{gm}+\lambda\alpha=U-P_{ngm}+\mu\alpha \Rightarrow \alpha_{gm}= (P_{ngm}-P_{gm})/\mu-\lambda$ is indifferent in consuming either one unit of a GM product or a non-GM product. As reflected from Figure 3.2, consumers with a differentiating attribute $\{0,a_s\}$ would rather have the substitute product, consumers located between $\{a_s,a_{gm}\}$ prefer the GM products and consumers located in the interval $\{a_{gm},1\}$ prefer the organic counterpart. The consumption share of GM products is expressed as:

$$X_{gm} = a_{gm} - a_s \Rightarrow X_{gm} = \frac{\lambda P_{ngm} - \mu P_{gm}}{\lambda(\mu-\lambda)} \tag{8}$$

While the consumption share for the non-GM products is:

$$X_{ngm} = 1 - a_{gm} \Rightarrow X_{ngm} = \frac{\mu - \lambda - P_{ngm} + P_{gm}}{\mu - \lambda} \tag{9}$$

From equations (8) and (9) it is noticeable that, the higher the P_{ngm}, the greater the quantity demanded for the GM products, and the higher the P_{gm}, the greater the demand for non GM products. In order to permit positive market share for both products, we assume that $P_{gm} < P_{ngm}$ and $\mu > \lambda$. Consumer aversion is assumed to be greater than the price difference $(\mu - \lambda) > (P_{ngm} - P_{gm})$, otherwise (if the price difference is greater than consumer aversion), the non GM products would be eliminated from the market.

The aggregate consumer surplus is the area under the effective utility curve depicted in Figure 3.2 by the dashed line and is written as:

$$CS = \int_0^{as} U_s d\alpha + \int_{as}^{agm} U_{gm} d\alpha + \int_{agm}^{1} U_{ngm} d\alpha \tag{10}$$

3.2.5 Retailers' Decisions Before Changing the AP Thresholds

While for consumers the purchasing decision depends on the utility, farmers´ decisions depend on the net returns which each product ensures. In the case where purity thresholds are zero, producing non-GM products for farmers causes high costs which, subsequently, the processors and the retailers will be charged for. Recent researches (Kalaitzadonakes and Magnier, 2004; Giannakas and Kalaitzandonakes, 2005) have shown that the production and segregation costs are affected by the Purity standards.

Consumers' inverse demands are derived by solving equations (8) and (9) for P_{gm} and P_{ngm}.

$$P_{gm} = \frac{\lambda P_{ngm}}{\mu} - \frac{\lambda(\mu - \lambda) X_{gm}}{\mu} \tag{11}$$

$$P_{ngm} = P_{gm} + \mu - \lambda - (\mu - \lambda) X_{ngm} \tag{12}$$

Using consumer inverse demand for the GM product equation (11), we can write the GM retailer's profit function as:

$$\pi_{gm} = (\frac{\lambda P_{ngm}}{\mu} - \frac{\lambda(\mu-\lambda)X_{gm}}{\mu}) * X_{gm} - c_{gm} * X_{gm} \quad (13)$$

The first order condition for maximizing equation (13) is:

$$\pi' = \frac{\lambda P_{ngm}}{\mu} - \frac{(1+\theta_{gm})\lambda(\mu-\lambda)}{\mu} X_{gm} - c_{gm} = 0 \quad (14)$$

Equation (14) solved for the X_{gm} gives us the GM supplied quantity expressed as:

$$X_{gm} = \frac{\lambda P_{ngm} - \mu c_{gm}}{\lambda(\mu-\lambda)(1+\theta_{gm})} \quad (15)$$

On the other hand, using consumer inverse demand for non-GM products, equation (12), we write the non-GM retailer profit function as follows:

$$\pi_{ngm} = (P_{gm} + \mu - \lambda - (\mu-\lambda)X_{ngm}) * X_{ngm} - c_{ngm} * X_{ngm} \quad (16)$$

The first order condition for maximizing equation (16) is

$$\pi' = P_{gm} + \mu - \lambda - (\mu-\lambda)(1+\theta_{ngm})X_{ngm} - c_{ngm} = 0 \quad (17)$$

Finally, equation (17) solved for X_{ngm} gives the non-GM supplied quantity which is written as follows:

$$X_{ngm} = \frac{P_{gm} + \mu - \lambda - c_{ngm}}{(\mu-\lambda)(1+\theta_{ngm})} \quad (18)$$

Equations (15) and (18) indicate that the supplied products X_{gm} and X_{ngm}, are in a righteous proportion with the opposite prices. The greater the P_{gm} the greater the quantity of non-GM product supplied and the greater the P_{ngm}, the greater the quantity of GM products supplied.

3.2.6 Market Equilibriums when the Purity Thresholds are Assumed to be Zero

Having determined the functions of both consumers and producers for GM and non-GM products we equate them in order to derive market equilibrium prices and quantities.

Product demand:

$$X_{gm} = \frac{\lambda Pngm - \mu Pgm}{\lambda(\mu-\lambda)}$$

$$X_{ngm} = \frac{\mu-\lambda-Pngm+Pgm}{\mu-\lambda}$$

Product supply:

$$X_{gm} = \frac{\lambda Pngm - \mu Cgm}{\lambda(\mu-\lambda)(1+\theta gm)}$$

$$X_{ngm} = \frac{Pgm+\mu-\lambda-Cngm}{(\mu-\lambda)(1+\theta ngm)}$$

To derive the market outcome both market sides are equated. The demand and supply functions are already determined and listed above. Particularly, equating equations 8 and 15, the following formula is obtained:

$$P_{gm} = \frac{\lambda P_{ngm}\,\theta_{gm} + \mu c_{gm}}{\mu(1+\theta_{gm})} \qquad (19)$$

Equating equation 9 and equation 18 results in the following formula

$$P_{ngm} = \frac{\{(P_{gm}+\mu-\lambda)\,\theta_{ngm} + c_{ngm}\}}{1+\theta_{ngm}} \qquad (20)$$

The simultaneous solution of these two equations results in the following closed-form solutions (see also Giannakas and Kalaitzandonakes, 2005):

$$PE_{gm} = \frac{\lambda*\theta_{gm}*\theta_{ngm}*\mu-\lambda^2*\theta_{gm}*\theta_{ngm}+\lambda*\theta_{gm}*c_{ngm}+\mu*c_{gm}*\theta_{ngm}+\mu*c_{gm}}{\mu*(1+\theta_{gm}+\theta_{ngm})+(\mu-\lambda)*\theta_{gm}*\theta_{ngm}} \qquad (21)$$

$$PE_{ngm} = \frac{(c_{gm}*\theta_{ngm}+\mu*\theta_{ngm}+\mu*\theta_{gm}*\theta_{ngm}-\lambda*\theta_{ngm}-\lambda*\theta_{gm}*\theta_{ngm}+c_{ngm}+c_{ngm}*\theta_{gm})*\mu}{\mu*(1+\theta_{gm}+\theta_{ngm})+(\mu-\lambda)*\theta_{gm}*\theta_{ngm}} \qquad (22)$$

$$XE_{gm} = \frac{\mu*(\lambda*\mu*\theta_{ngm}-\lambda^2*\theta_{ngm}+\lambda*c_{ngm}-\mu*c_{gm}-\mu*c_{gm}*\theta_{ngm}+\lambda*c_{gm}*\theta_{ngm})}{\lambda*(\mu-\lambda)*(\mu*(1+\theta_{gm}+\theta_{ngm})+(\mu-\lambda)*\theta_{gm}*\theta_{ngm})} \qquad (23)$$

$$XE_{ngm} = \frac{\lambda*\theta_{gm}*c_{ngm}+\mu^2*\theta_{gm}-\lambda*\mu*\theta_{gm}-c_{ngm}*\mu*\theta_{gm}+c_{gm}*\mu+\mu^2-\mu*c_{ngm}-\mu*\lambda}{(\mu-\lambda)*(\mu*(1+\theta_{gm}+\theta_{ngm})+(\mu-\lambda)*\theta_{gm}*\theta_{ngm})} \qquad (24)$$

Some comparative statistical results are indicative: An increase either in market power or in marginal costs results in an increase in the prices of both GM and non-GM products. $\frac{\delta P_i}{\delta \theta_i} > 0$, $\frac{\delta P_j}{\delta \theta_i} > 0$, $\frac{\delta P_i}{\delta c_i} > 0$, $\frac{\delta P_j}{\delta c_i} > 0$, for i, j $\in$ {gm, ngm} but the change in θ_i, c_i affects P_i more than P_j so $\frac{\delta P_i}{\delta \theta_i} > \frac{\delta P_j}{\delta \theta_i}$; $\frac{\delta p_i}{\delta c_i} > \frac{\delta p_j}{\delta c_i}$. On the other hand, the greater θi is, the lower X_i will be, and the greater the counterpart product X_j is: $\frac{\delta X_i}{\delta \theta_i} < 0$, $\frac{\delta X_i}{\delta \theta_j} > 0$. The more market power the retailers have, the smaller the equilibrium quantity they have to produce and higher the price they charge selling it. Similarly, as c_i increases X_i decreases while the quantity of X_j increases: $\frac{\delta X_i}{\delta c_i} < 0$, $\frac{\delta X_i}{\delta c_j} > 0$.

So far, we have derived market equilibriums under oligopoly retailing market structure assuming farmers and processors as price takers. Equations 21, 22, 23 and 24 indicate the important role that the market power has in the equilibria. The greater the market power the greater the price of the oligopolistic firm while the smaller the equilibrium quantity. Sexton and Zhang (2001) attested that even modest levels of market power when applied at multiple stages of the market channel in the food industry, can interact to shift the distribution of welfare among farmers, marketers and consumers drastically. Furthermore, we introduce in our model a vertical market power level in order to see how equilibrium prices and quantities, as well as consumer, retailer and processor welfare will be affected by this additional oligopolistic power.

3.3 Market characteristics in Vertical Oligopoly

3.3.1 The Market Structure

In this section, we consider a market channel where a primary GM or non-GM product is procured from farmers by a processing sector, transferred then to the retailer who offers the final product to the consumer, where final users have the choice of GM and non-GM foods. Similarly to the previous model, the model we develop envisions competitive farmer and consumer. But in this section we assume to have imperfect interactions between the retailer and processor. The scenario where retailer may exercise oligopolistic power over consumers, and processor may exercise oligopolistic power over retailers is the second subcase analyzed. Given the model structure the working scheme is meant to be as follows:

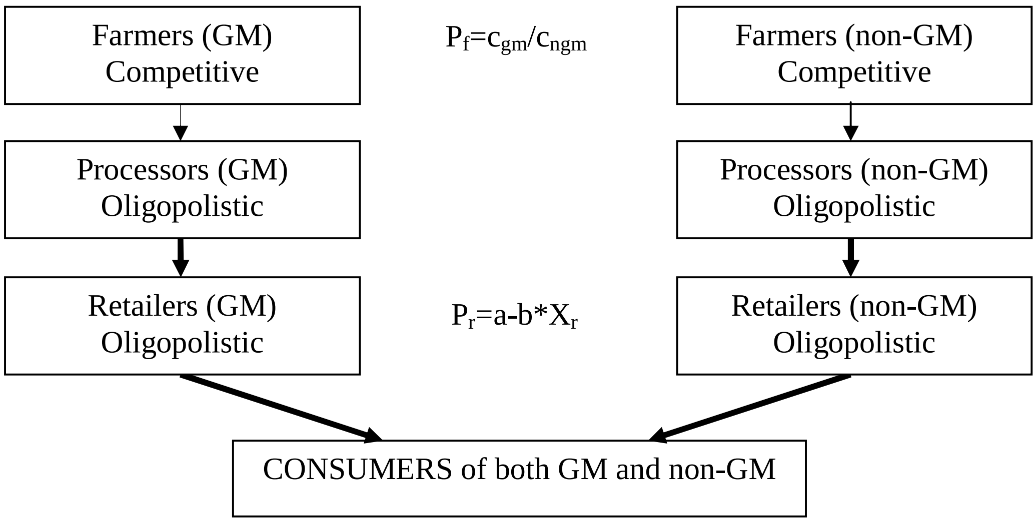

Figure 3.3: Market structure in a Vertical Oligopolistic Market

Source: Own calculations

Where ↓ indicates price taking, and ↓ indicates market power.

The chain analyzed here is comprised of many farmers who sell their products to a few processors. Perfect competitive interactions are assumed to take place between farmers and processors, whereas successive oligopoly is assumed to flow downstream: market power is exercised by processors towards retailers and by retailers towards consumers. This market structure could be justified in a situation where few processors/wholesalers exercise market power to a relatively large number of retailers who are spread out in different countries as it can be a large market (e.g. the EU or the USA market). However, retailers operate in spatial oligopolies in their local markets (e.g. Denmark, Greece, etc.) where they can exercise market power towards local consumers. This is illustrated in Figure 3.3. As in the previous horizontal oligopoly model (Figure 3.1), we have two separate chains for GM and non-GM products. The only common point between both chains is consumers. The main interest is to examine how the welfare of consumers, retailers and processors is affected by purity standards under the vertical oligopolistic market structure.

3.3.2 The Model

As mentioned earlier, consumers are assumed to be price takers and their demand depends on their utility maximization. Basically, consumer demand for GM and non-GM products is defined in the same way as for a horizontal oligopoly and is specified by equations 8 and 9. On the other hand, consumers' inverse demand is defined by equations 11 and 12. To focus the model on the possible implications of market power, we assume that both the retailer and processor use fixed proportions and constant return technology. We assume that $X_r = X_w = X_e$ where the subscripts r, w and e indicate the retail, wholesaler and equilibrium output, respectively. Given our assumptions, the representative processor's variable cost is written as:

$$C_w = c_w * X_w + c_i * X_w \qquad (25)$$

Where c_w represents the constant processing cost per unit, c_i indicates farmers´ total cost for both GM and non-GM products, and X_w represents wholesalers´ quantity. A representative retailer's variable cost function is expressed as:

$$C_r = c_r * X_r + P_w * X_r \qquad (26)$$

Where c_r represents the constant retailing cost per unit, X_r is the retailing output, P_w indicates wholesaler price.

3.3.3 Retailers' Characteristics in a Vertical Oligopoly

As previously mentioned, processors have market power versus retailers. In this case, indicating the retailers´ cost is higher than in the case where processors are competitive price takers. Nevertheless, retailers do not have power to change it. That's why they are represented as price takers versus wholesalers. The fact that retailers have market power versus consumers makes them able to affect the price. For the subcase of vertical oligopoly power, a representative retailer's profit function can be expressed as:

$$\pi_r = P_r * X_r - c_r * X_r - P_w * X_r \qquad (27)$$

Using consumer inverse demand for GM products, from equation (11), we derive the GM retailer profit function as follows:

$$\pi_{rgm} = \left[\lambda * \frac{P_{rngm}}{\mu} - \lambda * \frac{\mu-\lambda}{\mu} * X_{gm}\right] * X_{gm} - c_{rgm} * X_{gm} - P_{wgm} * X_{gm} \tag{28}$$

The first order condition for maximizing equation (28) is:

$$\pi' = \lambda * \frac{P_{rngm}}{\mu} - \lambda * \frac{\mu-\lambda}{\mu} * X_{gm} * \left(1 + \theta_{rgm}\right) - c_{rgm} - P_{wgm} = 0 \tag{29}$$

Equation (29) solved for P_{wgm} represents GM retailer inverse demand which is expressed as:

$$P_{wgm} = \lambda * \frac{P_{rngm}}{\mu} - \lambda * \frac{\mu-\lambda}{\mu} * X_{gm} * \left(1 + \theta_{rgm}\right) - c_{rgm} \tag{30}$$

Similarly, using non-GM consumer inverse demand, equation (12), the representative retailer's profit maximization for the non-GM products is given as:

$$\pi_{rngm} = [P_{rgm} + \mu - \lambda - (\mu - \lambda) * X_{rngm}] * X_{ngm} - c_{rngm} * X_{ngm} - P_{wngm} * X_{ngm} \tag{31}$$

The first order condition for maximizing equation (31) is as follows:

$$\pi' = P_{rgm} + \mu - \lambda - c_{rngm} - (\mu - \lambda) * \left(1 + \theta_{rngm}\right) * X_{ngm} - P_{wngm} = 0 \tag{32}$$

Equation (32) solved for P_{wngm} represents non-GM retailer inverse demand which is:

$$P_{wngm} = P_{rgm} + \mu - \lambda - c_{rngm} - (\mu - \lambda) * \left(1 + \theta_{rngm}\right) * X_{ngm} \tag{33}$$

3.3.4 Processors' (Wholesalers´) Characteristics

Processors perform all the relevant marketing functions between the farm level and the retail level. Farmers are assumed to be competitive in our model so the price that processors pay to them equals the market price. Furthermore, the cost faced by processors is taken as a constant. Farmers' prices for which wholesalers are charged, are introduced in the vertical oligopoly model as c_{gm} for GM products and c_{ngm} for non-GM products. In addition, $\theta_{wngm/wgm}$ is introduced in the model to capture the wholesaler's market power on the retailer. It ranges from 0 to 1; a value of $\theta_{wngm/wgm}$ equaling 1 corresponds to a monopoly wholesaler while a value of it equaling 0 corresponds to a perfect competitive (price taking) wholesaler. On the other hand, the price they charge the retailer is not constant; it depends on wholesaler quantity. The representative processor's profit function is given as:

$$\pi_w = P_w * X_w - c_w * X_w - c_i * X_w \tag{34}$$

Using the GM retailer inverse demand, equation (30), the GM wholesaler profit function is written as follows:

$$\pi_{wgm} = \left[\lambda * \frac{P_{rngm}}{\mu} - \lambda * (\mu - \lambda) * \left(1 + \theta_{rgm}\right) * \frac{X_{gm}}{\mu} - c_{rgm}\right] * X_{gm} - c_{wgm} * X_{gm} - c_{gm} * X_{gm} \tag{35}$$

The first order condition for maximizing equation (35) is:

$$\pi'_{wgm} = \lambda * \frac{P_{rngm}}{\mu} - \lambda * (\mu - \lambda) * \left(1 + \theta_{rgm}\right) * \frac{X_{gm}}{\mu} * \left(1 + \theta_{wgm}\right) - c_{rgm} - c_{wgm} - c_{gm} = 0 \tag{36}$$

From equation (36) the GM supplied quantity is derived as follows:

$$X_{gm} = \frac{\lambda * P_{rngm} - \mu * c_{rgm} - \mu * c_{wgm} - \mu * c_{gm}}{\lambda * (\mu - \lambda) * \left(1 + \theta_{wgm}\right) * \left(1 + \theta_{rgm}\right)} \tag{37}$$

The same procedure is applied for deriving the non-GM wholesaler profit function.

Starting from the non-GM retailer inverse demand, the non-GM wholesaler profit function can be expressed as:

$$\pi_{wngm} = \left[P_{rgm} + \mu - \lambda - c_{rngm} - (\mu - \lambda) * \left(1 + \theta_{rngm}\right) * X_{ngm}\right] * X_{ngm} - c_{wngm} * X_{ngm} - c_{ngm} * X_{ngm} \tag{38}$$

The first order condition for maximizing equation (38) is:

$$\pi' = P_{rgm} + \mu - \lambda - c_{rngm} - (\mu - \lambda) * \left(1 + \theta_{rngm}\right) * \left(1 + \theta_{wngm}\right) * X_{ngm} - c_{wngm} - c_{ngm} = 0 \tag{39}$$

From equation (39) the equilibrium output supplied in the market is derived as follows:

$$X_{ngm} = \frac{p_{rgm} + \mu - \lambda - c_{rngm} - c_{wngm} - c_{ngm}}{(\mu - \lambda) * (1 + \theta_{rngm}) * (1 + \theta_{wngm})} \quad (40)$$

3.3.5 Market Equilibriums

To derive the equilibrium demands and prices for GM and non-GM products we equate both the demand and supply functions represented by equations (8),(9), (37), (40) .

Specifically, equating Equation (8) with Equation (37), and Equation (9) with Equation (40), market equilibrium quantities and prices for both products are defined as follows:

$$PE_{gm} = \frac{\xi * \lambda * \left((c_{rngm} + c_{wngm} + c_{ngm}) + \mu * b - \lambda * b \right) + \mu * (c_{rgm} + c_{wgm} + c_{gm}) * \phi}{\xi * \left((\mu - \lambda) * b + \mu \right) + \mu * \phi} \quad (41)$$

$$PE_{ngm} = \frac{\left((c_{rngm} + c_{wngm} + c_{ngm}) * a + b * \left((c_{rgm} + c_{wgm} + c_{gm}) + (\mu - \lambda) * a \right) \right) * \mu}{\mu * \phi + \xi * (\mu + (\mu - \lambda) * b)} \quad (42)$$

$$XE_{gm} = \mu * \frac{b * (\mu - \lambda) * \left(\lambda - (c_{rgm} + c_{wgm} + c_{gm}) \right) + \lambda * (c_{rngm} + c_{wngm} + c_{ngm})}{(\mu - \lambda) * \lambda * (\xi * \left((\mu - \lambda) * b + \mu \right) + \mu * \phi} \quad (43)$$

$$XE_{ngm} = -\frac{(\mu - \lambda) * (\xi * (c_{rngm} + c_{wngm} + c_{ngm} - \mu) - \mu) + \mu * \left((c_{rngm} + c_{wngm} + c_{ngm}) - (c_{rgm} + c_{wgm} + c_{gm}) \right)}{(\mu - \lambda) * (\xi * \left((\mu - \lambda) * b + \mu \right) + \mu * \phi)} \quad (44)$$

where:

$$a = \theta_{wgm} + \theta_{rgm} + \theta_{wgm} * \theta_{rgm} + 1$$

$$b = \theta_{wngm} + \theta_{rngm} + \theta_{wngm} * \theta_{rngm}$$

$$\xi = \theta_{wgm} + \theta_{rgm} + \theta_{wgm} * \theta_{rgm}$$

$$\phi = \theta_{wngm} + \theta_{rngm} + \theta_{wngm} * \theta_{rngm} + 1$$

Equations (41), (42), (43), (44) exemplify the positive relation between the concentration of industries and the equilibrium price: $\frac{\delta P_i}{\delta \theta i} > 0 \text{ for }$ i∈ (w_{gm},r_{gm},w_{ngm},r_{ngm}). Similarly, these equations capture the negative relation between the degree of market power and the equilibrium quantity; $\frac{\delta X_i}{\delta \theta_i} < 0$ for i∈ (w_{gm},r_{gm},w_{ngm},r_{ngm}) as well as the negative relation between the concentration and the equilibrium sold quantity $\frac{\delta P_i}{\delta \theta i} > 0$; $\frac{\delta X_i}{\delta \theta_i} < 0$ for. The greater the wholesaler's market power versus retailers, the greater the price that retailers pay and, consequently, taking into consideration the market power retailers have versus consumers, the greater the price that consumers pay. The greater the market power of wholesalers over retailers, the smaller the equilibrium quantity.

In this chapter we have built the theoretical model for two different market structures. Firstly, the sub case of a horizontal oligopoly, assuming that the farmer, consumer and processor are price takers is analyzed, while assuming imperfect interactions between retailer and consumer. Secondly, we analyze the sub case of a vertical oligopoly, where perfect competitive interactions are assumed to take place between farmers and processors, and imperfect interactions are assumed to exist among processors, retailers and consumers. A successive oligopoly is assumed to flow downstream: market power is exercised by processors towards retailers and by retailers towards consumers. Equilibrium prices and outputs are derived and presented for each market structure for both GM and non-GM products. After having determined market equilibriums we need to define the impacts of Purity standards on them as well as the distribution of welfare among consumers, retailers and processors in both structures. In the next chapter, a simulation analysis is applied to clearly reflect AP threshold effects on market equilibria, consumer, retailer and processor welfare under different market structures. Purity standards equaling zero under perfect competition is our starting point, to followed by increased AP thresholds under different levels of market power. Particularly, specific scenarios of AP threshold effects under different market structures will be presented in Chapter 4.

CHAPTER 4

SIMULATION RESULTS OF MARKET AND WELFARE EFFECTS AFTER CHANGE OF PURITY STANDARDS

A simulation analysis will be conducted in this chapter in order to display analytically and graphically all the possible effects of different AP thresholds combined with different market power values. As previously mentioned, our benchmark is zero AP thresholds under Perfect competition. Furthermore, we assume the non-GM products as not being 100 % pure in order to indicate how the purity standards affect the market and welfare distribution. That is, non-GM products are allowed to contain up to a certain adventitious presence of GM material. Increased purity standards decrease the production cost and enhance non-GM food utility. It is assumed that processing costs will be lower as a more adventitious presence is allowed. The cost of non-GM products before and after changing the purity standards will be c_{ngm} and c'_{ngm}, respectively, where $c'_{ngm} < c_{ngm}$. However, producing non-GM products with a certain GM allowance is less preferred by the consumers. Utility enhancement for the non-GM products before and after changing the purity standards will be μ and μ', respectively, where $\mu' < \mu$. The equilibrium conditions after changing the purity standards can be derived by substituting μ' and c'_{ngm} for μ and c_{ngm}. Specifically, when the AP thresholds change the non-GM products' utility decreases, and this is shown as follows:

$$\mu' = \mu * (1 - u_e) \tag{45}$$

where u_e represents the utility effect of an increase in AP thresholds, μ' is the utility enhancement of non-GM foods after the increase of purity standards. u_e takes on a value from 0 to 1 ($0 < u_e < 1$), where 0 captures zero change in AP thresholds (that means after AP thresholds increase, non-GM products offer exactly the same utility enhancement), and 1 captures the highest increase in AP thresholds (in the case where after AP thresholds increase, non-GM products offer zero utility enhancement). The greater the amount of GM allowance (the greater the AP thresholds), the higher the u_e, resulting in a smaller u`.

The cost effect of an increase in AP thresholds is given by:

$$c_{ngm}' = c_{ngm} * (1 - c_e) \tag{46}$$

where c_e represents the non-GM production cost effect of an increase in AP thresholds, which ranges from 0 to 1 ($0 < c_e < 1$). Similarly, $c_e = 0$ indicates the case of no change in the AP thresholds, while 1 represents the highest GM allowance. The greater the AP thresholds, the greater the c_e and as a result the lower the c_{ngm}`

The assumptions respected throughout the analysis are:

I. $PE_{ngm} > PE_{gm}$

II. $\mu > \lambda$

III. $\mu - \lambda > PE_{ngm} - PE_{gm}$

IV. $\frac{PE_{ngm}}{PE_{gm}} > \frac{\mu}{\lambda}$

Given these assumptions, it is possible for both GM and non-GM products to have a positive market share. In addition, respecting constraints I-IV above, we invoke the normalizations that are available without loss of generality by choosing units so that:

$$\lambda = 6{,}3\,,\ \ \mu = 15\,,\ \ c_{gm} = 0{,}5\,,\ \ c_{ngm} = 3 \qquad (47)$$

Finally, three scenarios per each market structure are implemented in this analysis to include all the possible effects of AP thresholds:

- Both c_{ngm} and μ are affected in the same way by purity standards, i.e. u_e=0,1 and c_e=0,1.
- c_{ngm} is affected more than μ, i.e. c_e=0,5 and u_e=0,1
- μ is affected more than c_{ngm}, i.e. u_e=0,4 and c_e=0,1

4.1 Purity Standard Effects in Market Equilibria under Perfect Competition, Monopoly, Oligopoly and Vertical Oligopoly

Specifically, four different market structures are considered here starting from Perfect competition, and followed by Monopoly, Oligopoly and finally Vertical Oligopoly. We begin with the simplest market structure assuming perfect competitive interactions between consumers and retailers and retailers and processors, continuing with the introduction of different levels of market power and finally, concluding with the introduction of vertical market power within the supply chain. While we conduct our analysis based only on μ and c_{ngm} effects (AP thresholds effects), the market power takes on the value equal to zero ($\theta_{gm/ngm}$ =0),. The role of $\theta_{gm/ngm}$ is to reflect the importance of market power on market prices, outputs, consumer and retailer welfare. Thus, removing the market power from our analysis makes it possible to clearly define the direct market and welfare effects of AP thresholds (μ and c_{ngm}). In addition, Table 4.1 (page 47) contains all the calculations with respect to the specific scenario after Purity standards change in Perfect Competition, Monopoly, Oligopoly and Vertical Oligopoly.

Let a subscript 0 indicate the case of AP thresholds equal to zero; a subscript 1 indicate the case where u_e=0,1 and c_e=0,1; a subscript 2 indicate the case where c_e=0,5 and u_e=0,1; and a subscript 3 indicate the case where u_e=0,4 and c_e=0,1. $PE_{gm/ngm}$ and $XE_{gm/ngm}$ represent the equilibrium price and quantity, respectively, for both GM and non-GM products

4.1.1 Purity Standard Effects in Market Equilibria under Perfect Competition

When assuming the market power equaling zero, the market prices, outputs and distribution of welfare are determined solely by two parameters: μ (non-GM utility enhancement) and c_{ngm} (non-GM production cost). The curve $P_{gm}(\mu, \lambda, PE_{ngm}, X_{gm})$ represents the consumer sector's inverse demand for the GM final product at the retail level, while the curve $P_{ngm}(\mu, \lambda, PE_{gm}, X_{ngm})$ represents consumer sector's inverse demand for the non-GM product at the retail level.

Figure 4.1 graphs purity standard effects on the GM market. The inverse demand curves of both GM and non-GM products shift upward and downward depending on the magnitude of AP threshold effects on μ and c_{ngm} . The equilibrium price of GM products does not change after purity standards change. The reason is that GM retailers face a constant marginal cost which is insignificantly affected by AP thresholds under perfect competition. Therefore, because the equilibrium price equals the marginal cost, the AP thresholds do not affect the equilibrium prices of GM products. Because the u_e is very small, when scenario I ($u_e = c_e$) occurs, the intersect is insignificantly increased, while as is shown in Figure 4.1, the slope of the GM demand curve decreases. Thus, the total effect of scenario I is an increase on the quantity of GM product mostly produced because of the sleeper demand curve. When scenario II occurs the demand curve drastically shifts from P_{gm0} to P_{gm2}. This has mostly to do with the fact that the consumer will substitute GM with non-GM products due to the lower price that the the latter is offered at. Differently from scenario I the XE_{gm} decreases when ($c_e > u_e$). The opposite occurs under scenario III where the demand curve shifts upward from P_{gm0} to P_{gm3} indicating an increase on X_{gm}. The reason behind that is the fact that non-GM products lose market share when $u_e > c_e$, the pushing consumer to opt for GM products.

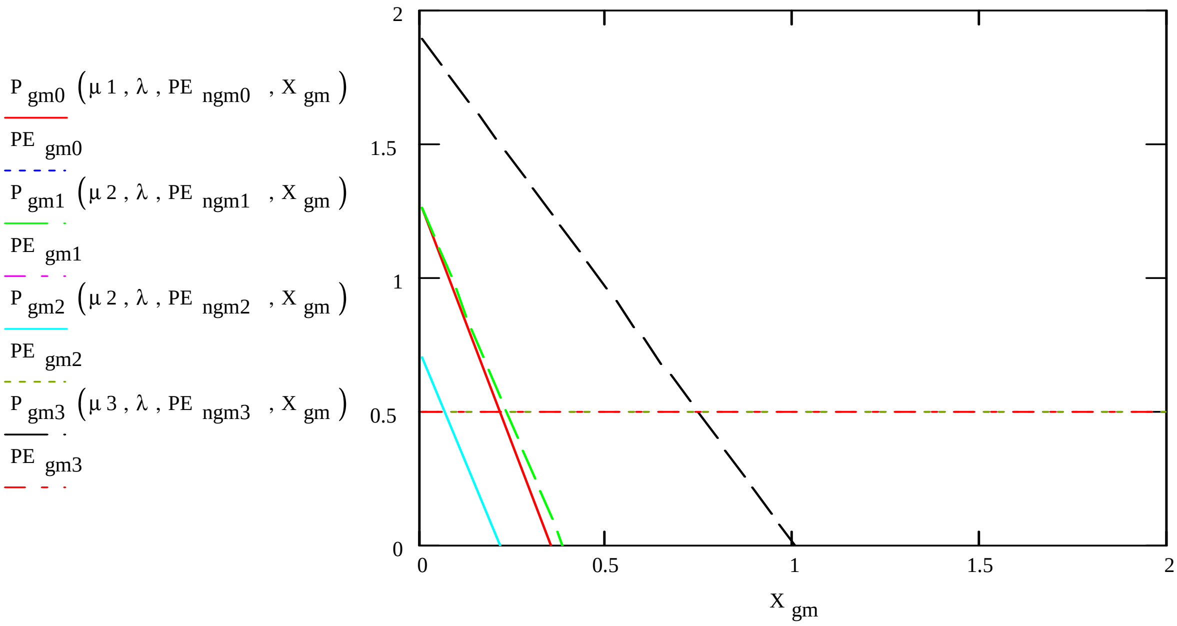

Figure 4.1: The effects of Purity Standards on the GM Perfect Competitive market

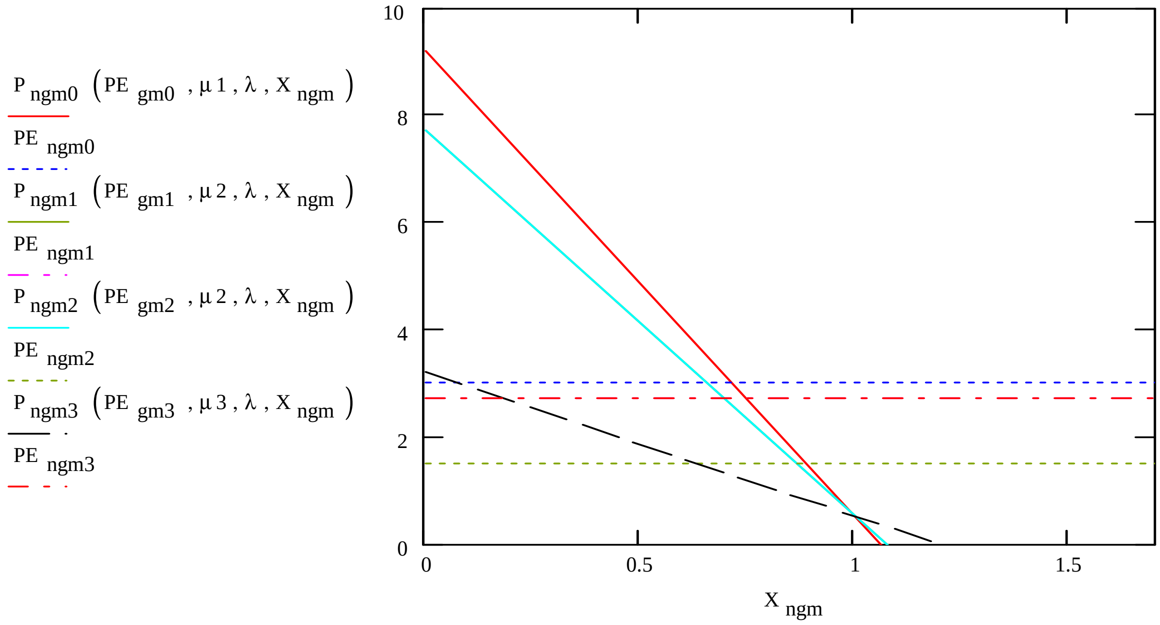

Figure 4.2: The effects of Purity Standards on the Non-GM Perfect Competitive market

Figure 4.2 displays AP threshold effects on equilibrium price and output in a non-GM product market. In the first scenario, when $u_e = c_e$, both the intercept and the slope of the demand curve decrease, PE_{ngm1} decreases compared to PE_{ngm0}, the demand curve P_{gm1} shifts down due to the decrease on μ which pushes a few consumers who were consuming non-GM products to buy GM products after the AP change, resulting in a decrease in non-GM quantity (XE_{ngm}). In the second scenario ($c_e > u_e$), the equilibrium price decreases from PE_{ngm0} to PE_{ngm2}, and this decrease is caused mostly because of cost reduction. The demand curve shifts downwards but because of the huge decrease on the prices, the quantity of non-GM products increases. The non-GM products are offered at a much lower price and with almost the same utility enhancement. Hence, the consumer differentiating attribute a_{gm} (Figure 3.2) shifts to the left indicating an increase in the consumption share of non-GM products. Non-GM products lose market share under scenario III ($u_e > c_e$), a_{gm} lifts on the right decreasing the non-GM consumption share. After losing utility enhancement, the consumers with a high aversion towards GM products will discontinue purchasing non-GM products.

4.1.2 Purity Standard Effects in a Monopoly

This section introduces the market power considering the case of a monopolistic retailer. So far we have seen the AP threshold effects on market equilibriums assuming zero market power within the supply chain. In contrast, considering the absolute retailing sector's market power, the analysis provides us with the information of how the AP thresholds affect the market prices and outputs when the retailer controls the price.

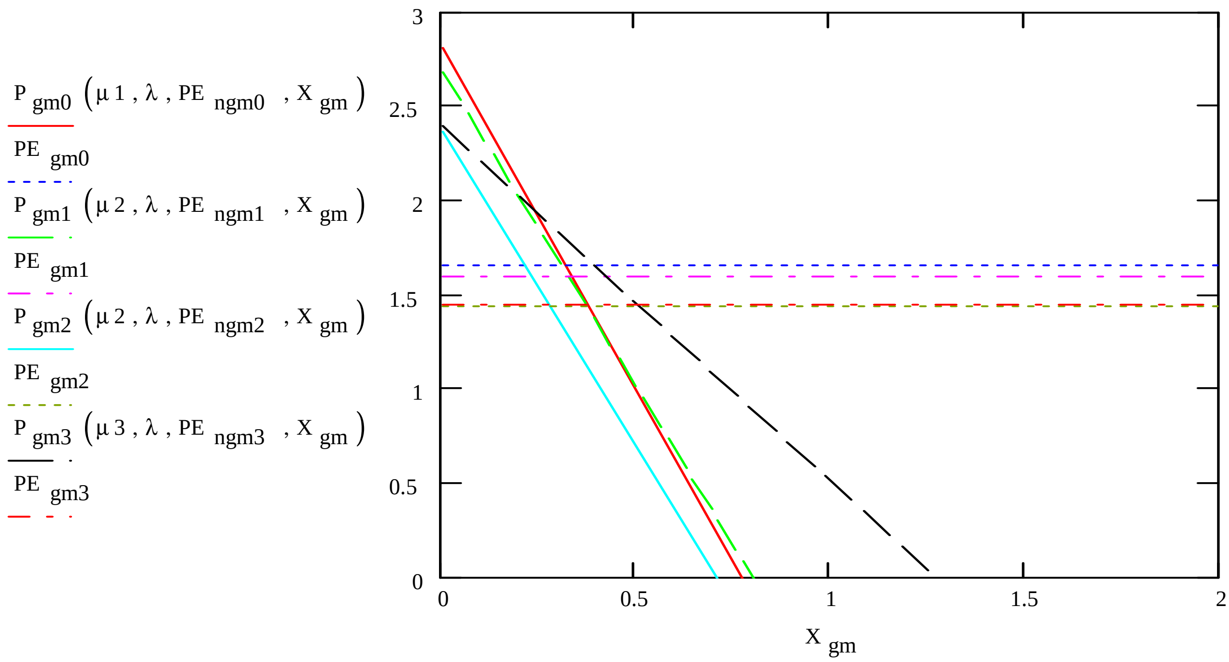

Figure 4.3 The effects of Purity Standards on the GM Monopolistic market

Figure 4.3 depicts market effects from an increase in the AP thresholds in the GM market. When scenario I ($u_e = c_e$) occurs, PE_{gm} decreases while XE_{gm} increases. In this setting, the reduced PE_{ngm} and μ slightly decrease the intersect and the slope of the demand curve. When scenario II occurs, P_{gm} shifts downward to P_{gm2} because the reduced PE_{ngm} and μ cause a drastic decrease in the intersect of the demand curve revealing a decrease in both PE_{gm} and XE_{gm}. In contrast with perfect competition, when scenario III ($u_e > c_e$) occurs, the intersect of the demand curve decreases. This reveals the fact that in this case, AP thresholds have affected the PE_{ngm} more than μ ($\Delta PE_{ngm} > \Delta\mu$). However, similarly to Perfect Competition, the PE_{gm} and XE_{gm} increase under scenario III, but absolutely not in the same amount/unit.

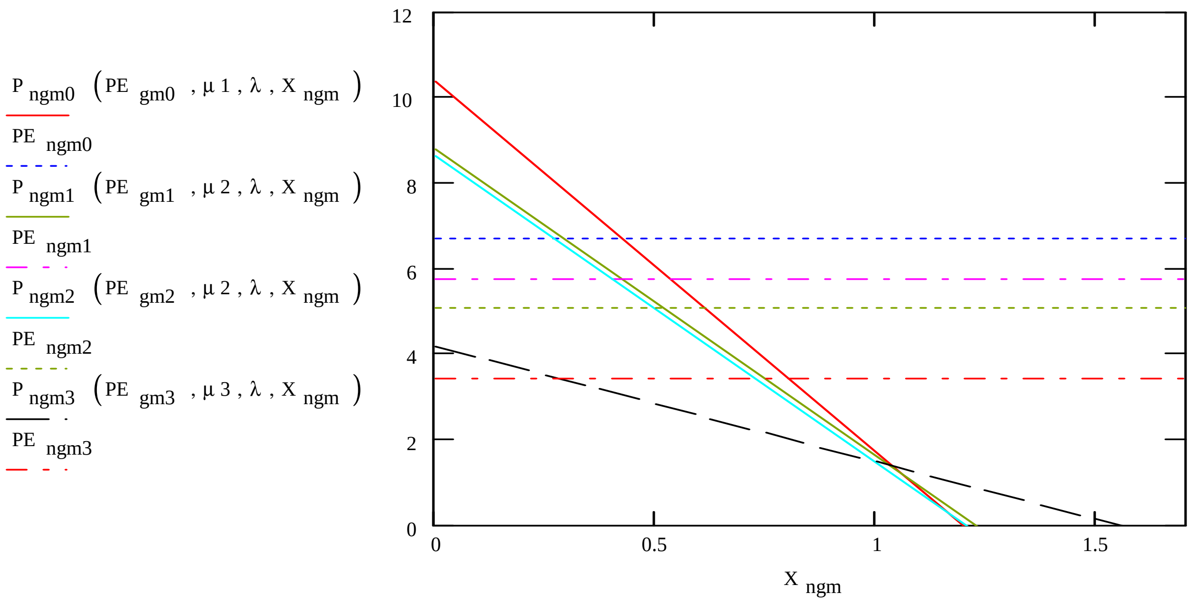

Figure 4.4: The effects of Purity Standards on the non-GM Monopolistic market

Figure 4.4 depicts the AP threshold effects on the non-GM market. Graphically, the increase on AP thresholds for the non-GM product causes a decrease of both the intersect and the slope of the demand curve when scenario I occurs. The equilibrium price of non-GM products decreases and this is depicted by the downward shift of PE_{ngm0} to PE_{ngm1}. On the other hand, the quantity of non-GM product increases because of the lower price. When scenario II ($c_e > u_e$) occurs both the intersect and the slope of the demand curve decrease defining a decrease on PE_{ngm} and an increase on XE_{ngm}. When $u_e > c_e$ is the case (scenario III), the intersect of the demand drastically decreases and so does the slope of the demand. Consumer preferences move towards GM products as a result of the much lower utility the non-GM products offer. Therefore, under scenario III the PE_{ngm} decreases (as indicated in the graph by the shift from PE_{ngm0} to PE_{ngm3}) and the same thing happens to the XE_{ngm}.

4.1.3 Purity Standard Effects in an Oligopoly

After representing the AP effects under two opposite market structures, we now consider the middle case. The market power is introduced as in a monopoly but in this case, with a lower value. The assumption made here is that there are a few retailers in the market (5 big retailing companies) which have a 20% share of the market. Simulating with all three key variables we define the values of AP threshold effects in an oligopolistic market structure for both GM and non-GM products.

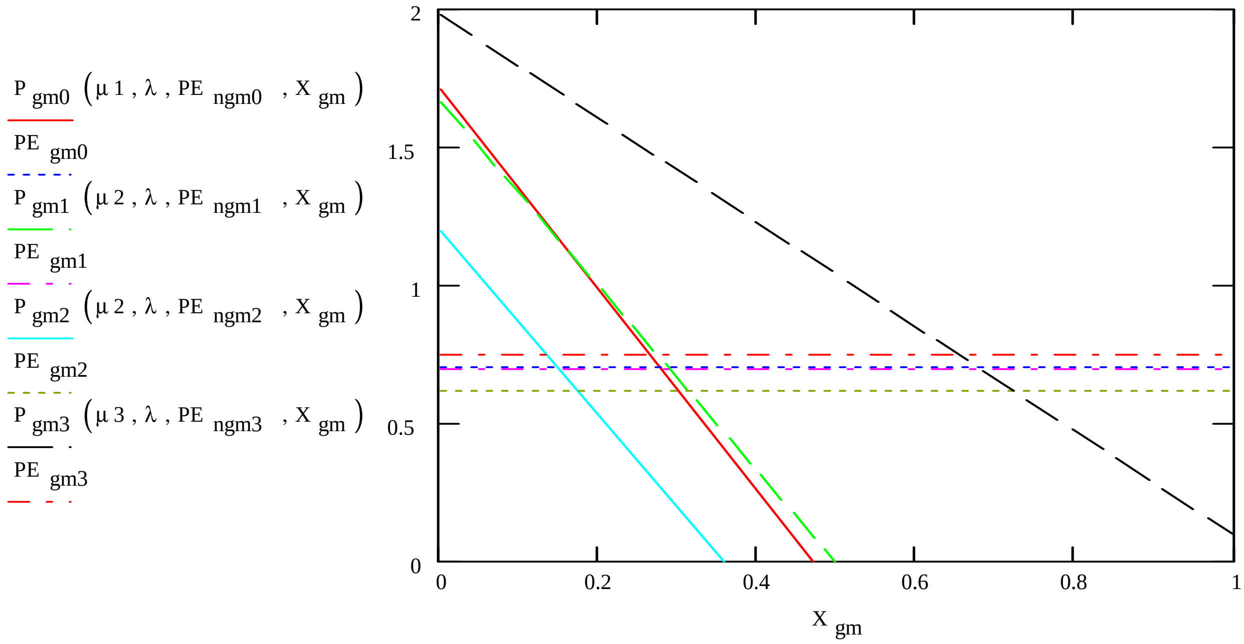

Figure 4.5: The effects of Purity Standards on the GM Oligopolistic market

Figure 4.5 depicts the AP threshold effects on the equilibrium price and quantity of GM products. Specifically, when the first scenario occurs, both the intersect and the slope of the demand curve decrease causing a decrease in the equilibrium price PE_{gm}, while the XE_{gm} increases. Similarly to scenario I, PE_{ngm} decreases under scenario II and so does the XE_{ngm}. When $c_e > u_e$ the PE_{ngm} drastically decreases due to the cost savings and that is the reason why the intersect of the demand curve greatly decreases. When scenario III occurs, the demand curve shifts upward, the intersect of the demand increases while the slope decreases. The red dashed line represents the specific case where the PE_{gm} increases after AP thresholds increase. Even though the price of GM increases, the quantity of GM increases too. This occurs because consumers tend to consume GM instead of non-GM products with a very small utility level.

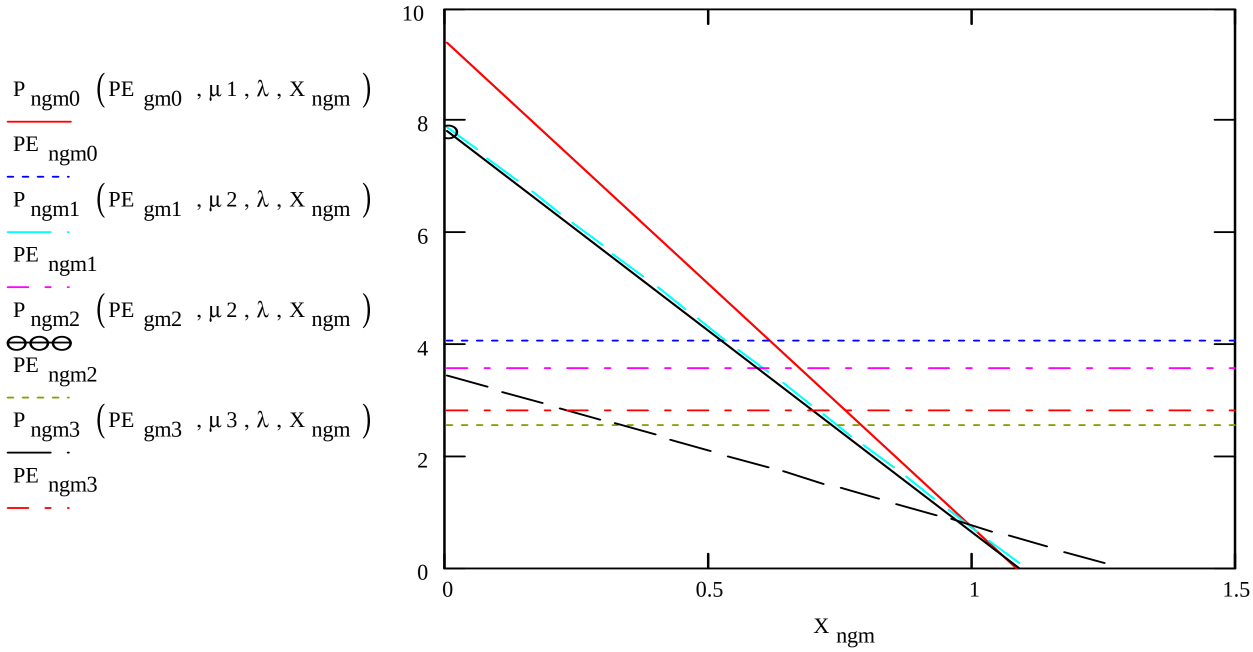

Figure 4.6: The effects of Purity Standards on the non-GM Oligopolistic market

Figure 4.6 depicts the AP threshold effects on a non-GM market. When the increase in the AP thresholds affects both utility and cost in the same amount (scenario I u_e=c_e) both PE_{ngm} and XE_{ngm} decrease because of the decrease in both the intercept and slope of the demand curve. When scenario II occurs ($c_e > u_e$) the intersect and the slope of the demand curve changes as in scenario I. On the other hand, the PE_{ngm} is significantly decreasing under scenario II. As a reason, we may mention the cost reduction making non-GM products more competitive in the market. Hence, the non-GM quantity increases because of the lower price they are offered in the market. In the last case, when $u_e > c_e$, the non-GM foods become less demanded and consumers use the GM counterpart as a substitute. As a result, PE_{ngm} decreases and so does the quantity of non-GM (XE_{ngm}).

4.1.4 Simulation Analysis in a Vertical Oligopoly

In this market structure, additional market power is applied in the supply chain. Our assumption regarding wholesalers is that there are two huge processing firms who supply many retailing companies, so they equally share the market (50%).

To focus the model on the implications of purity standard effects, we keep the same values for the former parameters and give the following values to the additional parameters:

c_{rngm}=0,1; c_{rgm}=0,1; c_{wgm}=0,1; c_{wngm}=0,1 (48)

Figure 4.7 depicts the AP threshold effect in a Vertical Oligopoly market structure. While the equilibrium price (PE_{gm}) decreases the equilibrium quantity increases when scenario I occurs. When scenario II occurs we see a downward shift of the P_{gm0} to P_{gm2} indicating a decrease in both equilibrium price (PE_{gm}) and quantity (XE_{gm}). This results from the great reduction cost on the non-GM production which causes a reduction on PE_{ngm} where the latter is the factor which shifts the demand down. When scenario III occurs the intersect of the demand incurs a small decrease while as we see from the graph (the black dashed line) the slope of the demand significantly decreases. Under these conditions as a final result we have a decrease in the PE_{gm}, and an increase in the XE_{gm}.

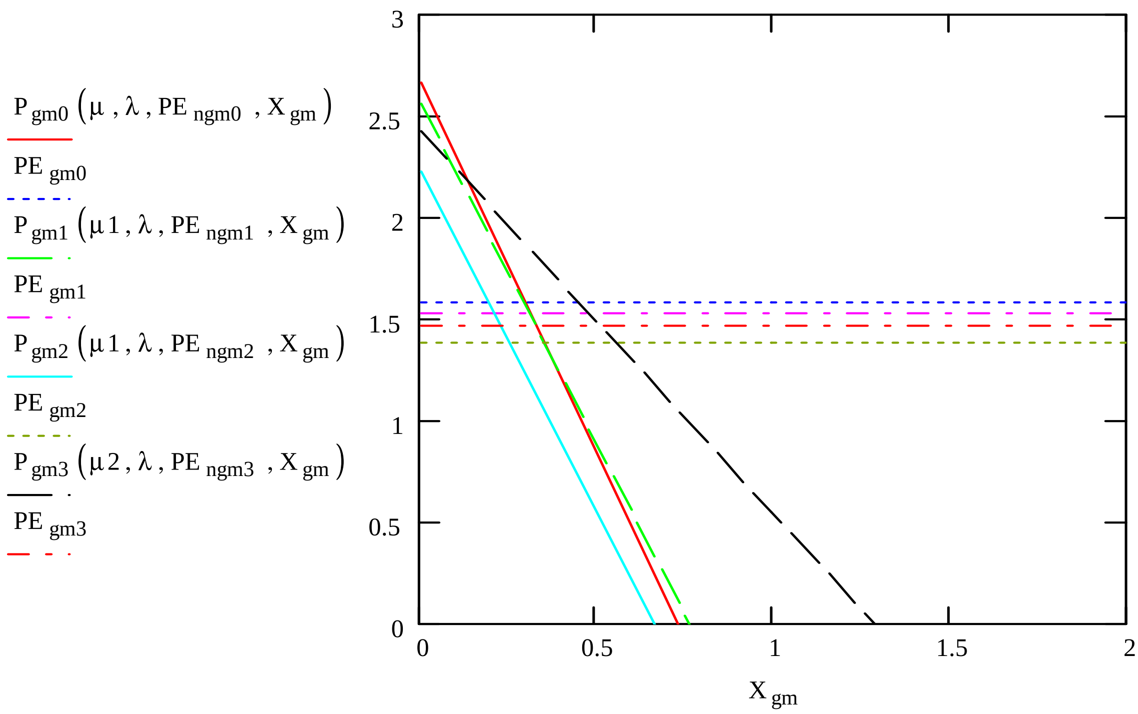

Figure 4.7: The effects of Purity Standards on the GM Vertical Oligopolistic market

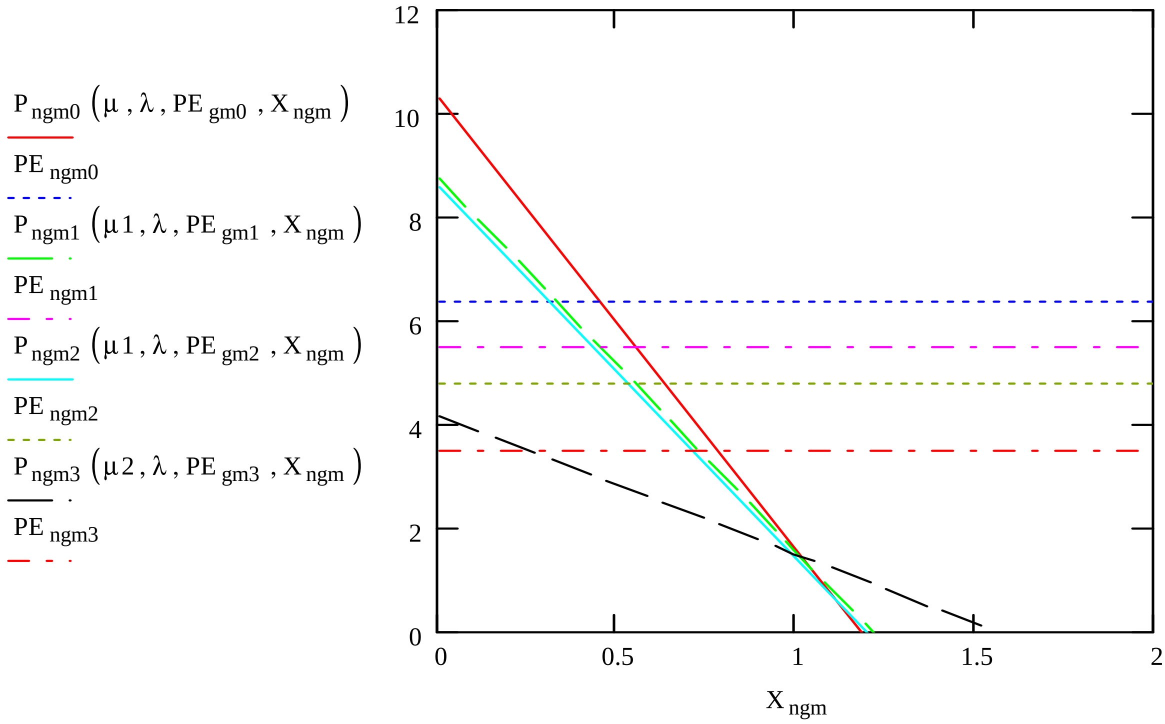

Figure 4.8: The effects of Purity Standards on the non-GM Vertical Oligopolistic market

What happens in a non-GM vertical oligopolistic market is graphed in Figure 4.8. The PE_{ngm} decreases in the three possible scenarios. The reason for the PE_{ngm} decrease is that both parameters, changing in all three scenarios, are positively related with it. Hence, as both of them decrease, PE_{ngm} decreases as well. When the first scenario occurs, the intersect and the slope of the demand decrease indicates a lower quantity (XE_{ngm}). In the second scenario where $c_e > u_e$, because of the great decrease in the price (PE_{ngm}), the quantity of non-GM products increases. In the case when $u_e > c_e$ (scenario III), the non-GM products lose their competitive advantage and become less requested in the market. A decrement in the demanded quantity of non-GM products by the consumers is obvious despite the lower price compared to the one before purity standards change. Within scenario III, both the price (PE_{ngm}) and the quantity (XE_{ngm}) decrease.

4.2. Consumer's and Retailer´s Surplus after the Purity Standards Change.

After having determined the AP threshold effects on market prices and outputs, we investigate the purity standard effects on consumer and retailer welfare of both GM and non-GM products. For this purpose, let a subscript (0) indicate consumers' and retailers´ surplus in the case where AP thresholds are zero. Consumer and retailer welfare will be displayed in this section respectively for the four market structures while the respective values are presented in Table 4.1 (pg.47).

4.2.1 AP Threshold Effects on Consumer Welfare under Different Market Structures

Under different market structures, consumers´ surpluses are determined by the following equations:

$$CS_{gm(i,j)} = \frac{1}{2} * \left(\frac{\lambda * PE_{ngm\,(i,j)}}{\mu} - PE_{gm\,(i,j)}\right) * X_{gm} \tag{49}$$

$$CS_{ngm(i,j)} = \frac{\left(\left(PE_{gm\,(i,j)} + \mu - \lambda\right) - PE_{ngm\,(i,j)}\right) * X_{ngm}}{2} \tag{50}$$

where i represents different market structures i={*perfect competition; monopoly; oligopoly; vertical oligopoly*}, while j induces the different scenarios j={*I; II, III*}. $PE_{ngm(i,j)}$ and $PE_{gm(i,j)}$ represent the equilibrium prices of GM and non-GM products. Each combination (i,j) presents information for a specific scenario (certain increase of AP thresholds) under a specific market structure (perfect competition, monopoly, oligopoly and vertical oligopoly). From equations (49) and (50) it follows that consumers´ surplus increases as the price of the counterpart product increases (i.e., GM consumer surplus increases while the price of non-GM products (PE_{ngm}) increases and the price of GM products (PE_{gm}) decreases). One reason is that some consumers may give up buying a perceived expensive product and so they substitute it for a more reasonable one. A consumer will move towards non-GM products in the case where the AP thresholds affect the production cost more than the utility. While moving towards the GM products, the AP thresholds reduce the utility of non-GM products more than their production cost. We must consider the fact that a consumer who has chosen to consume non-GM food has a high aversion towards GM material and so, in the case where non-GM is not considered as pure this type of consumer will give up consuming it. To sum up, we discuss below the consumer behaviors under both AP thresholds and market power effects which are presented in Figures 4.9 (GM products) and 4.10 (non-GM products).

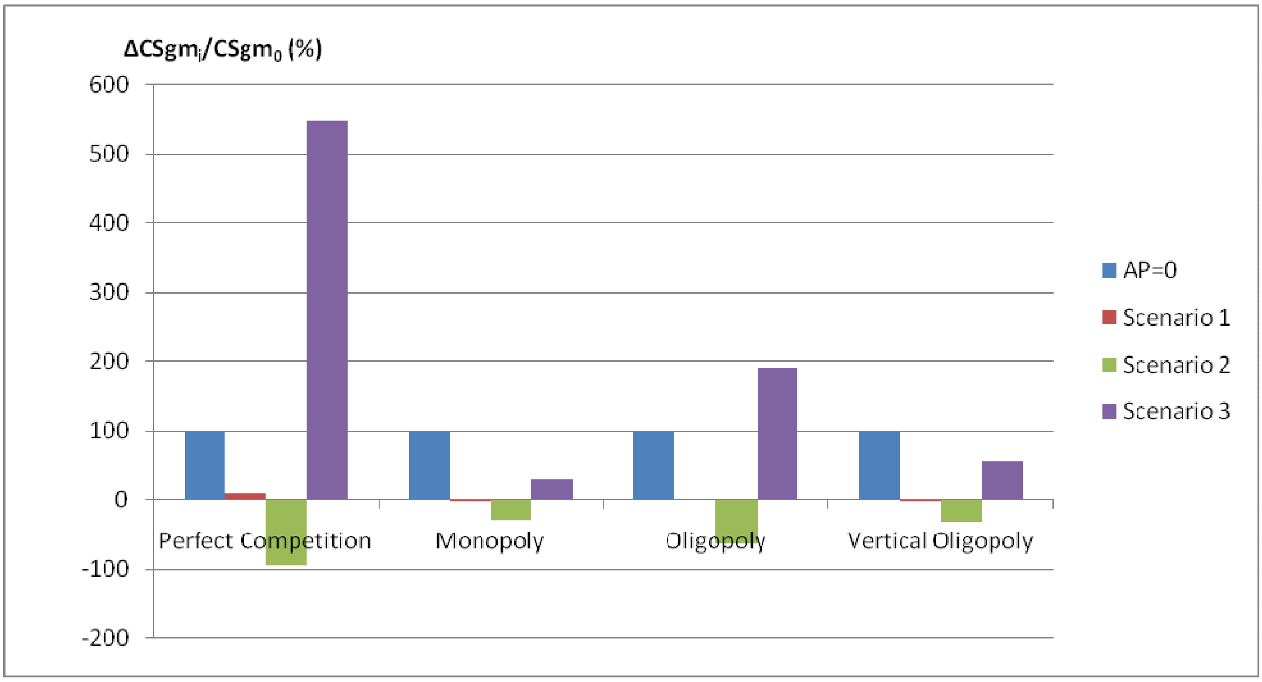

Figure 4.9: AP effects on GM consumers´ surplus in Perfect Competition, Monopoly, Oligopoly and Vertical Oligopoly

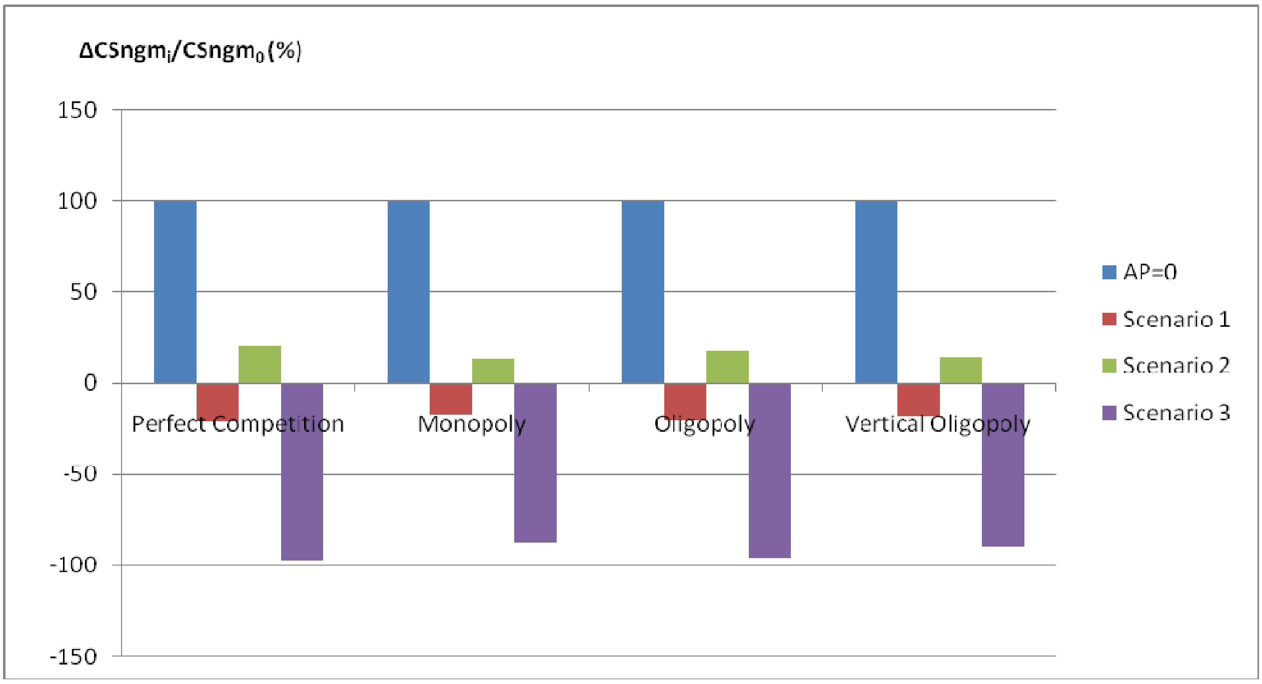

Figure 4.10: AP effects on Non-GM consumers´ surplus in Perfect Competition, Monopoly, Oligopoly and Vertical Oligopoly

It has to be pointed out that the impacts on the distribution of GM consumers´ welfare in a market of perfect competition are more severe than in the other market structures. Consumers either maximize or minimize their utility in perfect competition. The more market power is introduced in the supply chain, the less elastic the demand curve becomes and, consequently, consumers face fewer purchasing choices. Consumers with low aversion towards GM products, i.e. those who find it optimal to consume the GM products, gain surplus under scenario I, ($u_e = c_e$) in Perfect Competition and Oligopoly. However, they lose surplus in Vertical Oligopoly and Monopoly under this scenario. Also, these consumers lose surplus under scenario II in all market structures due to the fact that the non-GM products gain competitive advantages because of their significantly decreased production cost. Finally, these consumers are winners under scenario III in all market structures, with a maximum surplus occurring in a perfect competitive market. The set of non-GM consumers having a high aversion to GM foods, i.e. those who find it optimal to consume non-GM, lose their surplus under scenario I before and after an AP change in all four market structures. However, they do gain surplus under scenario II by paying (for almost the same perceived utility) much less than before the AP changed. Finally, they end up losing under scenario III by paying a high price for a product which doesn't enjoy their preferences as much as before.

4.2.2 AP Threshold Effects on Retailer Welfare under Different Market Structures

In our model, retailers are assumed to have a constant marginal cost, which as previously mentioned, is introduced in the model as $c_{gm/ngm}$ for both GM and non-GM products. Retailers´ surpluses for each scenario under different market structures are defined as follows:

$$PS_{gm(i,j)} = \left(PE_{gm(i,j)} - c_{gm}\right) * X_{gm} \tag{51}$$

$$PS_{ngm(i,j)} = \left(PE_{ngm(i,j)} - c_{ngm}\right) * X_{ngm} \tag{52}$$

$PS_{gm(i,j)}$ and $PS_{ngm(i,j)}$ varies depending on i (which represent the specific amount of GM allowance) and on the j (which represents the specific market structure). It follows from equations (51) and (52) that retailers´ surplus increase as the price of their products increases. However, we have mentioned above that the prices of GM and non-GM products are strategic complements. Thus, both prices move towards the same direction (either increase or decrease), but the percentage change is not equal for both products. When AP thresholds increase (and the cost reductions in the non-GM are higher) the demanded quantity of non-GM products is greater, thereby resulting in an increase in a non-GM retailer surplus. On the other hand, the larger the utility enhancement effect, the lower the equilibrium prices. The lower the demanded quantity for non-GM products results in a decrease of non-GM retailer surplus. For the GM retailers, their surplus increases in a way where the utility effect dominates and decreases when the opposite is true. Retailers' surplus for both GM and non-GM products under the four market structures are depicted in Figures 4.11 and 4.12.

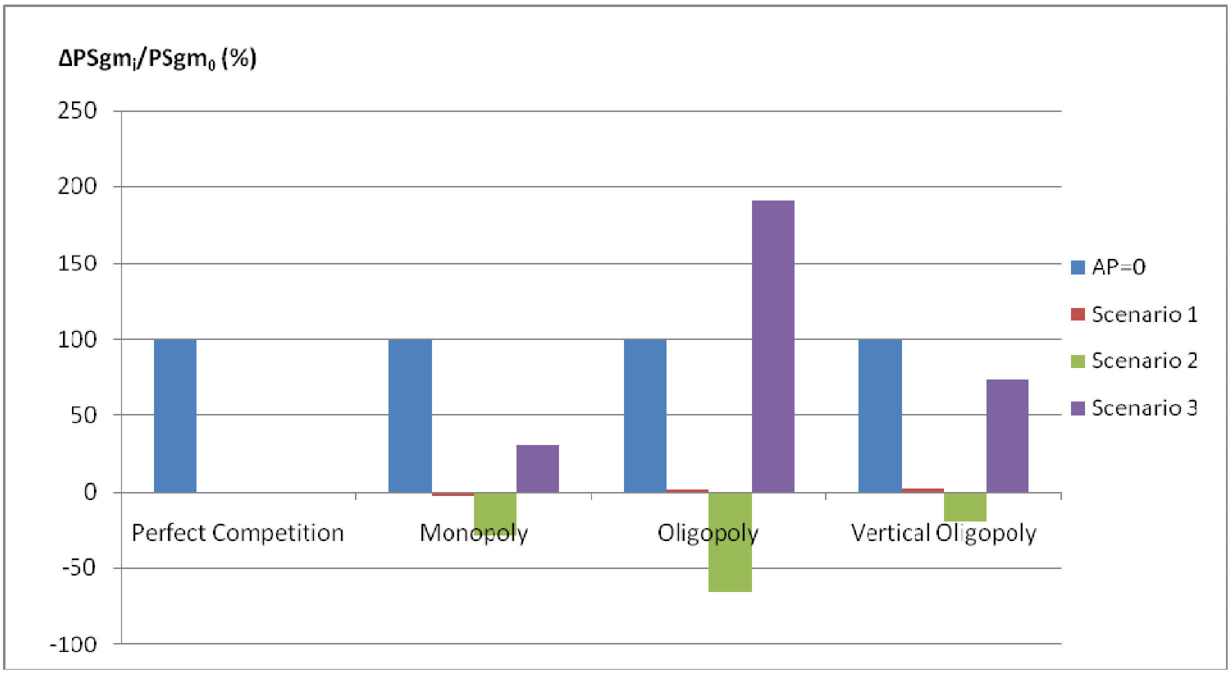

Figure 4.11: AP effects on GM Retailers´ surplus in a Perfect competition, Monopoly, Oligopoly and Vertical Oligopoly

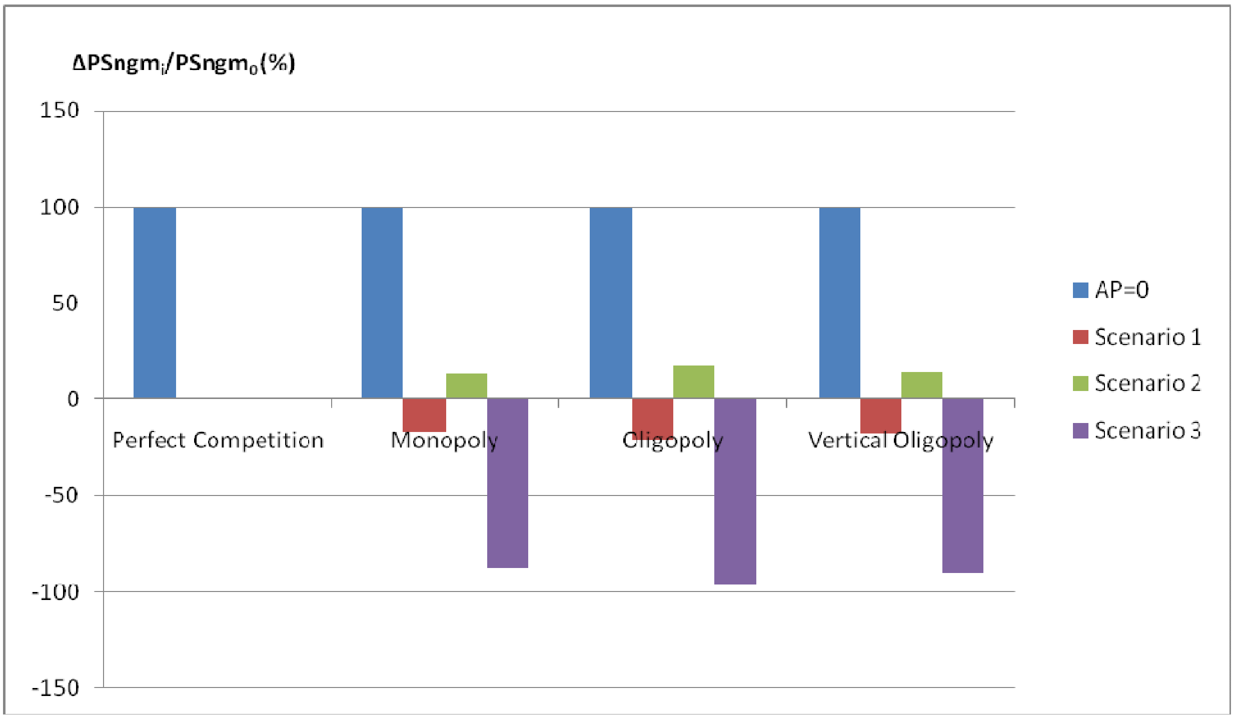

Figure 4.12: AP effects on non-GM Retailers´ surplus in Perfect Competition, Monopoly, Oligopoly and Vertical Oligopoly

It is depicted in Figure 4.11 that the surplus of the GM retailers is not affected by a purity standard change in perfect competition. The effects appear under scenario I as GM retailers gain a surplus in the oligopoly and in the vertical oligopoly market while the GM retailers lose their surplus in the monopoly.. Considering scenario II, these retailers lose their surplus in an oligopoly, vertical oligopoly and perfect competition market, where the maximum loss occurs within the Oligopoly. Finally, GM retailers earn their surplus under scenario III in the oligopoly, vertical oligopoly and monopoly, whereas the greatest surplus occurs within the oligopoly followed by the vertical oligopoly and monopoly, respectively.

Figure 4.12 depicts the AP effects on non-GM retailers´ surplus in a monopoly, oligopoly, perfect competition and vertical oligopoly. The impacts of the AP thresholds on non-GM retailers´ surplus in a perfect competition are zero under all scenarios. However, non-GM retailers lose their surplus under scenario I in the oligopoly, vertical oligopoly and monopoly markets. They attain their surplus under scenario II in the oligopoly, vertical oligopoly and monopoly due to the low cost and the increased demand for non-GM products. Finally, they lose their surplus under scenario III in the oligopoly, vertical oligopoly and monopoly.. The greatest loss is reported in the Oligopoly which indicates once more the role of market power in retail benefits.

To sum up, the market and welfare effects depend on the cost and utility effects and on the level of market power. Simulating with different values of cost and utility effects, we specified all the possible AP threshold effects. Furthermore, the different levels of market power introduced through the analysis have shown the total effect (AP thresholds effect + market power effect) on the equilibrium market and the welfare distribution as well where each scenario is considered as a specific sub case.

Table 4.1: Purity standard effects in a Perfect Competition, Monopoly, Oligopoly and Vertical Oligopoly

	$\mu´=\mu*(1-u_e)$	$C_{ngm}´=c_{ngm}*(1-c_e)$	PE_{gm}	PE_{ngm}	XE_{gm}	XE_{ngm}	CS_{gm}	CS_{ngm}	PS_{gm}	PS_{ngm}
Perfect Competition										
$U_e=c_e=0$	15	3	0,500	3	0,207	0,712	0,079	2,209	0	0
$u_e=c_e=0,1$	13,5	2,7	0,500	2,700	0,226	0,694	0,085	1,736	0	0
$u_e=0,1;c_e=0,5$	13,5	1,5	0,500	1,500	0,059	0,861	0,005	2,669	0	0
$u_e=0,4;c_e=0,1$	9	2,7	0,500	2,700	0,735	0,185	0,511	0,046	0	0
Monopoly										
$u_e=c_e=0$	15	3	1,652	6,676	0,315	0,422	0,182	0,776	0,363	1,553
$u_e=c_e=0,1$	13,5	2,7	1,590	5,745	0,324	0,423	0,177	0,644	0,354	1,288
$u_e=0,1;c_e=0,5$	13,5	1,5	1,432	5,066	0,277	0,495	0,129	0,883	0,258	1,766
$u_e=0,4;c_e=0,1$	9	2,7	1,448	3,242	0,501	0,268	0,237	0,097	0,475	0,194
Oligopoly										
$u_e=c_e=0$	15	3	0,701	4,066	0,275	0,613	0,138	1,635	0,055	0,654
$U_e=c_e=0,1$	13,5	2,7	0,693	3,565	0,288	0,601	0,140	1,301	0,056	0,520
$U_e=0,1;c_e=0,5$	13,5	1,5	0,615	2,552	0,171	0,730	0,049	1,923	0,019	0,769
$u_e=0,4;c_e=0,1$	9	2,7	0,746	2,824	0,651	0,230	0,400	0,071	0,160	0,028
Vertical Oligopoly										
$u_e=c_e=0$	15	3	1,573	6,343	0,363	0,451	0,198	0,887	0,181	0,354
$u_e=c_e=0,1$	13,5	2,7	1,527	5,490	0,378	0,449	0,195	0,727	0,186	0,291
$u_e=0,1;c_e=0,5$	13,5	1,5	1,375	4,755	0,322	0,530	0,135	1,013	0,146	0,405
$u_e=0,4;c_e=0,1$	9	2,7	1,466	3,462	0,639	0,260	0,306	0,091	0,314	0,036

CHAPTER 5

SUMMARY AND CONCLUDING REMARKS

5.1 Summary

In this thesis, a model of heterogeneous consumer preferences and heterogeneous retailer returns has been developed. The `pure` equilibrium prices and outputs correspond to a world where non-GM products are absolutely free of any GM material (GM allowance is zero). In our analysis, we acknowledged that the way in which purity standards affect the market and welfare depends on the magnitude of cost and utility effects, as well as on the market structure. An increase in the AP threshold has been proven to affect the demand and supply by reducing consumer trends towards the non-GM foods as well as non-GM production and segregation cost. Potential winners and losers are determined among consumers and producers of both GM and non-GM products. The simulation analysis indicated how changes in Purity Thresholds, within different market structures, no matter how small, can drastically shift the distribution of welfare among consumers and retailers of GM and non-GM products.

The aim of this study was to determine the impacts of AP thresholds in different market structures. For this purpose three possible impacts of AP thresholds are drawn under four possible market structures. Deriving the equilibrium prices and quantities under different market structures and parameterizing them with different values in order to induce the different scenarios of the AP effects, we have shown that each change on AP thresholds has different market and welfare effects.

5.2 Summary of Results

A key finding of this analysis is that changes, even though small, in AP thresholds do affect the equilibrium prices and quantities of both GM and non-GM products as well as consumers' and producers´ welfare. The impacts of AP thresholds in the markets of GM and non-GM products are case- specific and depend on:

1. the Non-GM product utility effect,

2. Non-GM production and segregation costs effect.
3. θi, i ∈ { rgm, rngm,wgm,wngm}– the market power within the supply chain of GM and non-GM products.

The expected results are as follows:

Scenario I: Cost and utility of non-GM products are affected in the same magnitude ($u_e = c_e$):

- in a Perfect Competition, PE_{gm} doesn't change, PE_{ngm} decreases, XE_{gm} increases, XE_{ngm} decreases. As a result a consumer who consumes GM products gains a surplus, while the consumer who would rather consume non-GM products could lose his surplus, and GM and non-GM retailers' profits do not change.
- in a Monopoly, PE_{gm} and PE_{ngm} decreases, both XE_{gm} and XE_{ngm} increase. As a consequence GM consumer (non-GM consumer) gains (lose) a surplus, and GM and non-GM retailers welfare decrease.
- in an Oligopoly, PE_{gm} and PE_{ngm} decreases, XE_{gm} increases, XE_{ngm} decreases, GM consumers expand their surplus, while non-GM consumers lose their surplus, GM retailer gain a surplus and non-GM retailer lose surplus.
- in a Vertical Oligopoly, both PE_{gm} and PE_{ngm} decrease, XE_{gm} increases while XE_{ngm} decreases. Consumer who consume either GM or non-GM products lose a surplus, GM retailer (non-GM retailer) gains (lose) a surplus.

Scenario II: The production cost of non-GM products is affected more than the utility of non-GM products ($u_e < c_e$). :

- in a Perfect Competition, PE_{gm} does not change, PE_{ngm} decreases, XE_{gm} decreases while XE_{ngm} increases. As a consequence GM consumer faces a welfare loss, while non-GM consumer realizes a welfare gain, and GM and non-GM retailers are not affected by purity standards
- in a Monopoly, both PE_{gm} and PE_{ngm} decrease, XE_{gm} decreases while XE_{ngm} increases. GM consumer lose the surplus while non-GM consumer gain a surplus, GM retailer lose their surplus while non-GM retailer gains a surplus.

- in an Oligopoly, both PE_{gm} and PE_{ngm} decrease, XE_{gm} decreases while XE_{ngm} increases As a result consumer of GM (non-GM) products loses (gains) surplus GM retailer lose a surplus, and non-GM retailer gain a surplus.
- in a Vertical Oligopoly, PE_{gm} and PE_{ngm} decreases, XE_{gm} decreases, XE_{ngm} increases, resulting in welfare losses (gains) for GM consumer (non-GM consumer) GM retailer lose surplus, non-GM retailer gain surplus.

Scenario III: The utility of non-GM products is affected more than the non-GM production cost ($u_e > c_e$):

- in a Perfect Competition, PE_{gm} does not change, PE_{ngm} decreases, XE_{gm} increases while XE_{ngm} decreases, GM consumer gains a surplus while non-GM ones lose a surplus, and similar to scenarios I and II, GM and non-GM retailers welfare is not affected by AP thresholds.
- in a Monopoly, both PE_{gm} and PE_{ngm} decrease, XE_{gm} increases while XE_{ngm} decreases, GM consumers' surplus increases while non-GM consumers' welfare decreases, GM retailers´ welfare increases while non-GM retailers lose a surplus.
- in an Oligopoly, PE_{gm} increases while PE_{ngm} decreases, XE_{gm} increases while XE_{ngm} decreases resulting in welfare gains (losses) for consumer and retailer of GM products (consumer and retailer of non-GM products)
- in a Vertical Oligopoly, both PE_{gm} and PE_{ngm} decreases, XE_{gm} increases while XE_{ngm} decreases resulting in welfare gains (losses) for GM consumer (non-GM consumer), GM retailer welfare increase, while non-GM retailer welfare decrease.

Another key finding, illustrated graphically and numerically in this thesis, is that the same scenario may have different market and welfare effects depending on the market structure they are applied to. Thus, it may be the case that the same group (consumers or producers) either supports or opposes an increase of AP thresholds depending on the structure of the market. Consumers who consume GM products would support the AP increase (scenario I) under perfect competition and oligopoly but on the other hand, they oppose the change under monopoly and vertical oligopoly due to their decrease in surplus. GM retailers face the same situation in scenario I. They gain a surplus under an oligopoly but they lose their benefits under a monopoly and vertical oligopoly. It is important to note that our results are similar to Giannakas and Kalaitzandonakes (2005), who showed that a change in the AP thresholds can create winners and losers not only among consumers but also among producers of both GM and non-GM products.

5.3 Limitations of the Study

This thesis analyses how consumers and retailers behave in four specific market structures after AP change, providing very detailed information about their behavior. However, further research would contribute to understanding the research in this field. A calibration of the model with real data would provide the policy markers with valuable insights on AP threshold effects. Possible extensions of this thesis include analyzing more chains in the supply channel, and engaging upstream and downstream market power in different chains.

5.4 Importance of the Study

This study represents the first attempt to systematically analyze the market and welfare of Purity Standards in an oligopoly and vertical oligopoly market structure. To analyze the AP threshold impacts on the market and welfare we have developed the model and conducted a simulation analysis for both GM and non-GM products. The results of this paper are useful for policy makers, consumers and producers of GM and non-GM products as they provide information for all the possible scenarios occurring after Purity Standards change. Moreover, knowing the possible market and welfare effects it is easier for the policy makers to choose the right food labeling law policy.

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