# Genetically modified foods in vertically differentiated and vertically oligopolistic markets

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# Introducing genetically modified foods in vertically differentiated and vertically oligopolistic markets

## 1. Introduction

In recent years many countries have adapted Labelling 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 labelling regime and the United States (US) which has chosen not to impose such requirements and implement a voluntary food labelling policy. Accepting the need for a labelling 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 EU countries adapted the most stringent policy requiring mandatory labelling 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 lowest GM allowance. Japan requires labelling for food products that contain more than 5% GM material (top three ingredients), followed by South Korea which requires labelling 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 AP thresholds affect consumer and producer welfare (Fulton and Giannakas, 2004; Lapan and Moschini, 2005/ 2006; Giannakas and Kalaitzandonakes, 2005).

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). While several studies (Giannakas and Fulton, 2002; Fulton and Giannakas, 2004,) refer to the GM issue, few of them (Lapan and Moschini, 2006/ 2007, Giannakas and Yiannaka, 2008; Giannakas and Kalaitzandonakes, 2005) have addressed the issue of regulatory standards in oligopolistic suppliers. To our knowledge, none have address oligopoly/oligopsony market structure.

The work closest to ours is that of Lapan and Moschini (2007) and Giannakas and Kalaitzandonakes, (2005). The former is dealing with the purity standards issue by assuming a perfectly competitive market for the GM and non-GM products, while the latter introduces an oligopolistic market. We extend Giannakas and Kalaitzandonakes, (2005) by introducing a conjectural variations oligopoly model similar to Sexton and Zhang (2001).

The aim of this paper is to determine the effects of purity standards of non-GM products on suppliers´ and consumers´ welfare under vertical oligopoly. In particular, 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 we show analytically the market and welfare effects of AP thresholds. Specifically, the following key components characterise our model:

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

## 2. Vertical Product Differentiation

The vertically differentiated consumer premise is that, whereas GM and non-GM products are offered at the same price, they will never choose the GM product. Meanwhile, some consumers are willing to pay some extra money to avoid GM food. 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 goods 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 sufficiently lower 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.

### 2.1 Consumer Characteristics

We 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:

$$U_{gm} = U - P_{gm} + \lambda\alpha \qquad \textit{if a unit of GM product is consumed} \qquad (1)$$

$$U_{ngm} = U - P_{ngm} + \mu\alpha \qquad \textit{if a unit of Non Gm product is consumed}$$

$$U_s = U \qquad \textit{if a unit of a substitute product is consumed}$$

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 $\lambda$ and $\mu$ capture the utility enhancement from consuming GM and non-GM foods, respectively;
- $\alpha$ 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.

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 $\alpha=0$ is indifferent in consuming one unit of substitute, GM or non-GM products.

As illustrated in Figure 1, 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: $\alpha_s$: $U_{gm}=U_s \Rightarrow U-P_{gm}+\lambda\alpha=U \Rightarrow \alpha_s = P_{gm}/\lambda$ is indifferent in consuming either a GM product or the substitute one. On the other hand, the consumer with the differentiating attributes: $\alpha_{gm}$: $U_{gm}=U_{ngm} \Rightarrow U-P_{gm}+\lambda\alpha=U-P_{ngm}+\mu\alpha \Rightarrow \alpha_{gm}=(P_{ngm}-P_{gm})/\mu-\lambda$ is indifferent in consuming either one unit of a GM product or a non-GM product. As shown in Figure 1, 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:

$$X_{gm} = a_{gm} - a_s \Rightarrow X_{gm} = \frac{\lambda P_{ngm} - \mu P_{gm}}{\lambda(\mu-\lambda)} \qquad (2)$$

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

$$X_{ngm} = 1 - a_{gm} \Rightarrow X_{ngm} = \frac{\mu-\lambda-P_{ngm}+P_{gm}}{\mu-\lambda} \qquad (3)$$

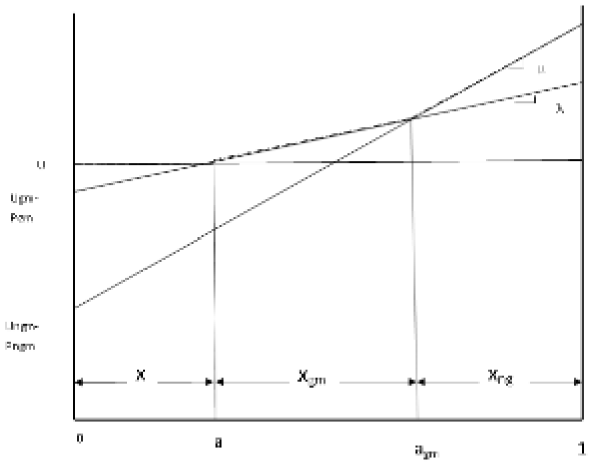


Figure 1: Vertically Differentiated Consumers´ choice

From equations (2) and (3) 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 nated from the market. The aggregate consumer surplus is the area under the effective utility curve depicted in Figure 1 by the dashed line and is written as:

$$CS = \int_0^{as} U_s d\alpha + \int_{as}^{agm} U_{gm} d\alpha + \int_{agm}^{1} U_{ngm} d\alpha \qquad (4)$$

**3. Oligopoly and Oligopsony**

The market power within a supply chain has impacts on market equilibrium and welfare distribution. Sexton and Zhang (2001) analyzed different market structures and showed 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:

$$P_{ri} = a - b * X_{ri} \tag{5}$$

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, farmers and processors are assumed to be price takers. Thus, we derive the implications of oligopoly/oligopsony power in the retailing sector, on market equilibriums and distribution of welfare among consumers, retailers and processors.

**3.1 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 $c_{ngm}$. These differences stem from various factors such as geography, education, management skills and the technology adopted (Fulton and Gianakas 2004).The production and segregation cost that a GM supplier faces is smaller than the one that a non-GM supplier does. 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:

$$\pi_r = P_r * X_r - c_r * X_r - P_w * X_r \tag{6}$$

Where $P_r$, $X_r$ ,$c_r$, and Pw represent retailer price, quantity and cost, and the processor price respectively. In our model we assume oligopsony market power exercised over processors, expressing the Pw as a function of the Xr. Exploring the profit maximization function of the processors, which are assumed to be price takers, we define the Pw as equal to the processor marginal cost. We follow the same approach as Fulton and Giannakas (2004) assuming a positive and constant marginal cost for GM and non GM processors.

Consumers' inverse demands are derived by solving equations (2) and (3) for $P_{gm}$ and $P_{ngm}$.

$$P_{gm} = \frac{\lambda P_{ngm}}{\mu} - \frac{\lambda(\mu-\lambda)X_{gm}}{\mu} \tag{7}$$

$$P_{ngm} = P_{gm} + \mu - \lambda - (\mu - \lambda)X_{ngm} \tag{8}$$

Using consumers inverse demands, equation (7) for the GM product and equation (8) for the Non-GM product, we can write the GM and Non-GM retailer's profit function as follow:

$$\pi_{gm} = \left(\frac{\lambda P_{ngm}}{\mu} - \frac{\lambda(\mu-\lambda)X_{gm}}{\mu}\right) * X_{gm} - -c_r * X_{gm} - c_{gm(X_{gm})} * X_{gm} \tag{9}$$

$$\pi_{ngm} = (P_{gm} + \mu - \lambda - (\mu - \lambda)X_{ngm}) * X_{ngm} - c_{rngm} * X_{ngm} - c_{ngm(X_{ngm})} * X_{ngm} \tag{10}$$

Equations (9) and (10) solved for the $X_{gm}$ and $X_{ngm}$ respectively give us the GM and Non-GM supplied quantity expressed as:

$$X_{gm} = \frac{\lambda P_{ngm} - \mu c_{rgm} - \mu c_{gm}(1+\xi_{gm})}{\lambda(\mu-\lambda)(1+\theta_{gm})} \tag{11}$$

$$X_{ngm} = \frac{P_{gm} + \mu - \lambda - c_{rngm} - c_{ngm}*(1+\xi_{ngm})}{(\mu-\lambda)(1+\theta_{ngm})} \tag{12}$$

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).

$\xi_i = \frac{\Delta C_i}{\Delta q} * \frac{q}{C_i}$ ; {i=gm, ngm} represent the oligopsony market power. It takes on values between 0 (perfect competition) to 1 (monopoly)

$c_{gm}$ and $c_{ngm}$ are the marginal costs of GM and non-GM products, respectively, faced by the processors of these products. $c_{rgm}$ and $c_{rngm}$ represent the retailers additional costs for both GM and Non-GM products respectively.

Equations (11) and (12) indicate that the supplied products $X_{gm}$ and $X_{ngm}$, are in the right 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.

The simultaneous solution of Equations 2, 3, 11, 12 results in the following closed-form solutions:

$$PE_{gm} = \frac{\lambda*\theta_{gm}*(\theta_{ngm}*(\lambda-\mu)-c_{ngm}*(1+\xi_{ngm})-c_{rngm})-\mu*(1+\theta_{ngm})*(c_{rgm}+c_{gm}*(1+\xi_{gm}))}{-\mu*(1+\theta_{gm}+\theta_{ngm})-\theta_{gm}*\theta_{ngm}*(\mu-\lambda)} \quad (13)$$

$$PE_{ngm} = \mu * \frac{((1+\theta_{gm})*(\theta_{ngm}*(\lambda-\mu)-c_{ngm}*(1+\xi_{ngm})-c_{rngm})-\theta_{ngm}*(c_{gm}*(1+\xi_{gm})+c_{rgm}))}{-\mu*(1+\theta_{gm}+\theta_{ngm})-\theta_{gm}*\theta_{ngm}*(\mu-\lambda)} \quad (14)$$

$$XE_{gm} = \mu * \frac{(\mu-\lambda)*(\theta_{ngm}*(\lambda-c_{gm}*(1+\xi_{gm}))-c_{rgm})-\mu*(c_{gm}+c_{rgm}*(1+\theta_{ngm}))+\lambda*c_{ngm}*(1+\xi_{ngm})}{\lambda*(\mu-\lambda)+\mu*(1+\theta_{gm}+\theta_{ngm})-\theta_{gm}*\theta_{ngm}*(\mu-\lambda)} \quad (15)$$

$$XE_{ngm} = \frac{(\mu-\lambda)*(\mu*(1+\theta_{gm})-\theta_{gm}*[c_{ngm}*(1+\xi_{ngm})+c_{rngm}])+\mu*(c_{gm}*(1+\xi_{gm})-c_{ngm}*(1+\xi_{ngm})+c_{rgm}-c_{rngm})}{(\mu-\lambda)*\mu*(1+\theta_{gm}+\theta_{ngm})+\theta_{gm}*\theta_{ngm}*(\mu-\lambda)} \quad (16)$$

Some comparative static 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.

$$\frac{\partial P_i}{\partial \theta_i} > 0; \frac{\partial P_j}{\partial \theta_i} > 0; \frac{\partial P_i}{\partial c_i} > 0; \frac{\partial P_j}{\partial c_i} > 0; \frac{\partial P_i}{\partial \xi_i} > 0; \frac{\partial P_j}{\partial \xi_i} > 0 \quad \text{for } i, j \in \{gm, ngm\} \quad (17)$$

but the change in $\theta_i$, $\xi_i$, $c_i$ affects $P_i$ more than $P_j$ , hence:

$$\frac{\partial P_i}{\partial \theta_i} > \frac{\partial P_j}{\partial \theta_i}; \frac{\partial P_i}{\partial \xi_i} > \frac{\partial P_j}{\partial \xi_i}; \frac{\partial P_i}{\partial c_i} > \frac{\partial P_j}{\partial c_i}. \quad (18)$$

On the other hand, the greater $\theta_i$ is, the lower $X_i$ will be, and the greater the counterpart product $X_j$ is: $\frac{\partial X_i}{\partial \theta_i} < 0; \frac{\partial X_j}{\partial \theta_i} > 0; \frac{\partial X_i}{\partial \xi_i} < 0; \frac{\partial X_j}{\partial \xi_i} > 0.$ (19)

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:

$$\frac{\partial X_i}{\partial c_i} < 0; \frac{\partial X_j}{\partial c_i} > 0. \quad (20)$$

## 4. Simulation results of market and welfare effects after change of purity standards

We conduct a simulation analysis in order to display all the possible market and welfare effects of AP thresholds. Our benchmark is zero AP thresholds; furthermore, we assume the non-GM products as not being 100 % pure. 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 the non-GM food utility as well. 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 μ′<μ. 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:

$$\mu' = \mu * (1 - u_e) \tag{21}$$

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 utility enhancement of Non-GM products ( 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:

$$c_{ngm}' = c_{ngm} * (1 - c_e) \tag{22}$$

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 followed throughout the analysis are:

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

II. $\mu > \lambda$

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

IV. $\frac{PE_{ngm}}{PE_{gm}} > \frac{\mu}{\lambda}$ (23)

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:

$$\lambda = 6\ ,\ \mu = 15\ ,\quad c_{gm} = 0{,}5\ ,\ c_{ngm} = 3 \tag{24}$$

**4.1 AP Threshold Effects on Consumer Welfare**

Mathematically we derive the GM and Non-GM consumers' welfare as follows:

$$CS_{gm} = \frac{1}{2} * \left(\frac{\lambda * PE_{ngm}}{\mu} - PE_{gm}\right) * X_{gm} \tag{25}$$

$$CS_{ngm} = \frac{\left((PE_{gm} + \mu - \lambda) - PE_{ngm}\right) * X_{ngm}}{2} \tag{26}$$

From equations (25) and (26) 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. The left panel of Figure 2, shows that Non-GM consumers, (those who have high aversion towards GM foods) are highly affected by the changes of the utility enhancement of the Non-GM. We see that a small change in the utility enhancement is highly affecting the consumer welfare. On the other hand the decrease in the non-GM production cost seems not to affect that much the Non-GM consumer welfare. A big change in the Non-GM cost is slightly affecting consumers' welfare.

As shown in the right panel of Figure 2, consumers who find it optimal to consume GM products are highly affected by the changes in the production cost of the Non-GM products and very slightly affected by the changes of the Non-GM utility enhancement. For those consumers who have a low aversion towards GM foods lose surplus when the Non-GM products became less expensive and they don't benefit from the decrease on the Non-GM utility enhancement.

### 4.2 AP Threshold Effects on Retailer Welfare

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. Mathematically retailers´ surpluses are defined as follows:

$$PS_{gm} = \left(PE_{gm} - c_{gm}\right) * X_{gm} \quad (27)$$

$$PS_{ngm} = \left(PE_{ngm} - c_{ngm}\right) * X_{ngm} \quad (28)$$

It follows from equations (27) and (28) that retailers´ surplus increase as the price of their products increases. However, as we have mentioned above 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. The results on welfare are shown in Figure 2.

Non-GM retailers are highly affected by the changes in both utility enhancement and the production cost of the Non-GM products. Their benefits depend on the magnitude of the AP thresholds effects in both utility and cost production. If the AP thresholds affect more the utility than the cost of the Non-GM foods then the Non-GM retailers will lose profits. Conversely if the AP thresholds affect more the cost of the Non-GM than their utility, the Non-GM retailers benefit.

GM retailers lose benefits when the Non-GM products become cheaper, and they experience a slight increase in their benefits when the utility of the Non-GM foods decreases. Due to lack of space we can not show all the graphs, however, we have calculated that in case the AP thresholds affect more the Non-GM cost the retailers of the GM products face a great loss of their profits. In case the AP thresholds affect more the utility of the Non-GM products, the GM retailers gain small benefits.

### 4.3 Market power effects on Consumer Welfare

Market power has negative effects on consumer welfare. In the following figures we try to depict the way consumers are affected by both, upstream and downstream market power. Space limitations do not allow us to show detailed results. The more market power is exercised in the supply chain, the more consumers lose surplus. Similarly to (Sexton and Zhang, 2001), we claim that the market power decreases consumer surplus. Particularly consumers lose welfare for paying higher prices for the same quality.

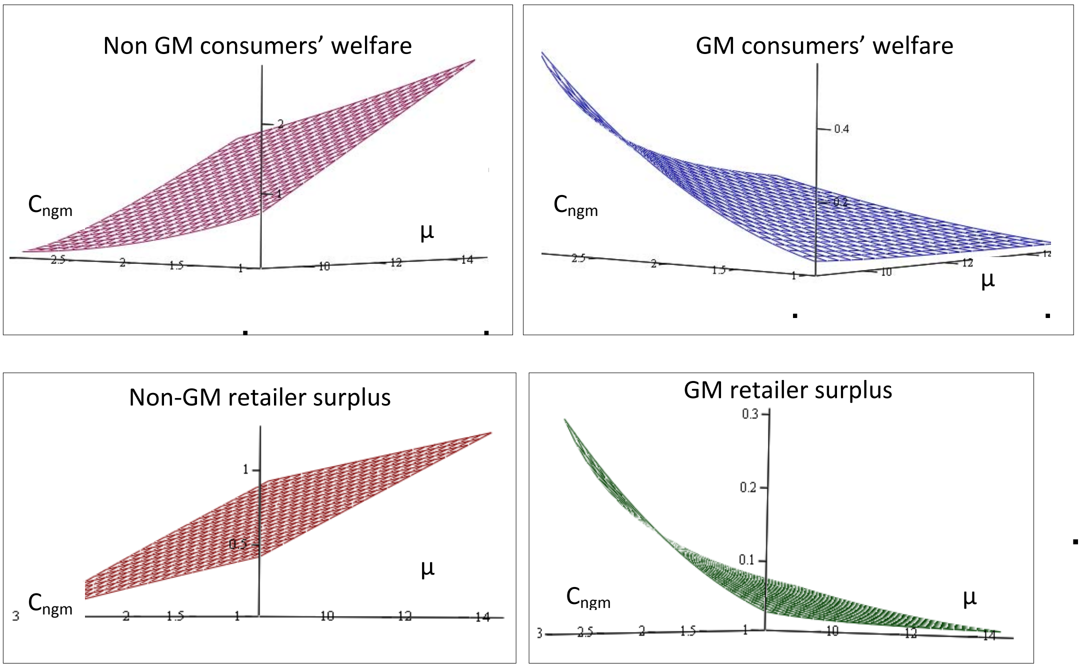


Figure 2. Effects of changing threshold levels on welfare

Differently from consumers' welfare effects, the market power raises retailers' benefits. The control they exercise over the price makes them able to achieve higher profits. We do not show this result due to lack of space.

**5. Summary and Conclusions**

In this paper, 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, no matter how small, can drastically shift the distribution of welfare among consumers and retailers of GM and non-GM products.

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. $\theta_i$, i ∈ { gm, ngm}- the downstream market power within the supply chain of GM and non-GM products
4. $\xi_i$, i ∈ { gm, ngm}- the upstream market power within the supply chain of GM and non-GM products.

Specifically, consumers who have high aversion towards GM products are mostly affected by the changes in the utility enhancement. The changes in the Non-GM cost don't influence them as much as the changes of the utility. These consumers are willing to pay a high price for ensuring their favorite quality. Similarly, the Non-GM retailers are affected highly by the changes in the utility and less affected by the price changes that result from the cost decrease. Consequently, the total surplus of the Non-GM consumer and retailer is highly affected by the utility and les affected by the cost of the Non-GM foods (Figure 10). The simulation analysis concludes that Non-GM consumers and retailers:

1. Lose surplus when the AP thresholds affect more the utility enhancement than the cost, $u_e > c_e$
2. Lose surplus when the AP thresholds affect in the same way both utility and cost $u_e = c_e$
3. Gain surplus when the AP thresholds affect the cost more than the utility $c_e > u_e$

On the other hand, GM consumers and retailers are highly affected by the changes on the Non-GM prices and less affected by the changes in the Non-GM utility. They gain surplus when the Non-GM offer less utility and their cost is high. As a result the total surplus decreases when the Non-GM products become less expensive, while it increases when the Non-GM products become less enjoyable (Figure 11). GM consumers and retailers are affected as follow:

1. Lose surplus when the AP thresholds affect more the cost than the utility $c_e > u_e$
2. Gain surplus when the AP thresholds affect both cost and utility in the same way $u_e = c_e$
3. Gain surplus when the AP thresholds affect the utility more than the cost $u_e > c_e$

Another key factor we analyzed is the market power, the ways it affect consumer and retailer welfare. Sexton and Zhang 2001 have concluded that the market power exercised within the supply chain has positive effect in the retailers 'profits and negative effects in consumers 'welfare. The total surpluses of both GM and Non-GM foods decrease as more market power is exercised within the supply chain. An increased oligopolistic or oligopsonic market power reduces the total welfare (Figure 12 and Figure 13).

Based on our analysis we suggest that Europea authorities perhaps shouldn't allow an increase of the AP thresholds. It is a fact that European consumers have a high aversion toward GM foods. An increase in the AP thresholds will make them giving up of buying those products, since they are not concerned about the lower prices as much as they are for the perceived high quality. These consumers are driven from the quality and that is what should not be affected. The businesses are also affected due to the lower demand for the Non-GM foods after the AP thresholds increase. Even though they control the market price, they lose profits due to the lower consumed quantity.

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