ΤΜΗΜΑ ΟΙΚΟΝΟΜΙΚΗΣ
ΕΠΙΣΤΗΜΗΣ

Perfect and imperfect labels in credence good markets with vertical relations and vertical differentiation

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Διατριβή υποβληθείσα προς μερική εκπλήρωση
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Abstract

In the present attempt there is an analysis in credence goods market. I assume that there is an upstream monopolist and two downstream firms. Consumers know that quality ranges but they do not know which of the firms supplies each quality. At first, there can be monopoly or duopoly in the downstream level. This depends on the efficiency of each firm and consumers' trust. Secondly, the introduction of a label can correct the lack of full information, but it can also decrease the profitability of the firms. Lastly, the upstream monopolist may have greater profits so as to encourage a monopoly in downwards market.

Introduction

Consumers used to buy products basing on their price and as a result they formed the demand function. In the meanwhile suppliers kept the same point of view, the one of price and in that way the equilibrium set. Nowadays budget constraint is not the only one of the factors for consumers' evaluation to goods, but more and more people are getting aware of the origin of the purchased goods. This worry about quality is especially focused on food, because it can cause irreversible consequences to health. Therefore, not only price is an important fact in making decisions, but quality as well. This happens because it is getting harder and harder to investigate the quality of goods. Consumers are in search of a better informational system revealing their inability of safe food verification and their necessity for healthy nutrition. One way restoring information is experience from everyday life and search that can minimize the amount of hazardous goods. Trusting retailers or consulting experts can be another way for grading products. However, we should take into consideration that understanding quality is difficult because of technological improvement. As a matter of fact, during last decades fertilizers and several other techniques have made the restoration of information difficult using the traditional techniques.

Firstly, Nelson[1] (1970) and Darby and Karni (1973) analyzed separately each good according to its characteristics[2]. Later, there was further classification of products in three main categories: search, experience and credence goods:

Search characteristics:	The quality can be ascertained by consumers before purchase
Experience characteristics:	The quality is learned after the good is bought. In this case information that has been acquired by the buyer can be used in repeated purchases.
Credence characteristics:	The quality is seldom clear even though consumption has been done. In this part

[1] Nelson hypothecates that there is more consumers' speculation about purchasing experience commodities than search ones. An empirical research confirms this thesis by Ford, Smith and Swasy in 1990. Darby and Karni expand this statement by focusing on the convenience with which people buy experience goods instead of credence products. Steenkamp examines this view in 1990.

consumer should trust a third party's certification or seller's credibility.

Owing the latter definition in Darby and Karni and Nelson according to Jean Tirole[3], credence goods are referred as "those which, although worthwhile, cannot be evaluated in normal use" because "they are expensive to judge even after purchase". They seemed to use the term "credence goods" instead of goods with credence characteristics. After all, consumers buy goods and not characteristics and the quality of goods is a bundle of the quality of these different characteristics. As it is difficult to analyze all the characteristics together, we focus on the one that we are interested in every case.

A simple example may help the reader to understand better the differences between the three categories. Assuming the product is a fruit then a search characteristic will be a squash or strange spots on its surface. An experience characteristic will be bitterness or "rubber" taste and a credence characteristic will be its production system to avoid genetically modified seeds.

However, the greatest the analysis the more problems rise. Since every good can be classified in all or almost all categories scientists face the problem of aggregation when they attempt to have an empirical analysis. Moreover, every product has innumerous characteristics and as a result time after time a different one may be more important than the others. For instance, somebody may bring in mind how important the place and the soil were that vegetables and fruit grew up when there was the explosion of the nuclear factory in Chernobyl (Ukraine) on the 26th of April 1986. For this reason, we refer to goods as credence goods when we focus on this kind of characteristics.

At present, technological development makes the investigation even harder. To clarify this we can bring in mind what Genetically Modified Organisms (GMO) is called. Using GMO goods become more long-lived on the one hand, but they can cause implications in humans' health as well. The consequences of GMO could be even worse especially if the goods are related to nutrition.

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[2] The characteristics approach (Lancaster 1966) supports that "a good can be described as a bundle of characteristics: quality, location, time, availability, consumers' information and so on"(Tirole. J., p.96 chapter 2, 1988)

[3] Tirole, J., p.106 chapter 2, (1988)

Another significant problem is that reputation cannot reveal the quality of credence good. Furthermore, purchasing, searching or signaling is not an effective way to achieve perfect information and provide the ability to consumers to be conscious about their goods. This means that reputation cannot be built and uncertainty exists between producers and consumers. In this point Dullek, Kerschbamer and Sutter (2009) got through a research that confirmed the above belief. They also found out that liability and competition among sellers is the most important factor in order trade to be further developed and reputation just follows.

The outcome is that if asymmetric information is not corrected, then the result will be a pooling equilibrium or otherwise a "lemons' problem"[4] would arise. This means that consumers have total ignorance about the goods that contain or not genetically modified organisms and therefore total ignorance about the danger. Thus, credibility to food is not enough and it is necessary some measures to be put into effect.

As a consequence there has been a lot of discussion about the solution of this problem. Scientists have had to answer a lot of questions about the appropriate measures that should have been or be taken. Firstly, the kind of certification is the greatest point. Somebody must choose between grading, minimum quality standards or labeling. Should there be a scale in the number of GMOs, a minimum level or a reference of containing? And if there is a label, ought it to be discrete or continuous? Moreover, there is speculation on whether a government can impose the obligation of it or if voluntary label is better. If so, should government be responsible for or can private firms provide equal or better services for social welfare? All the mentioned questions including the special cases of market structure (perfect competition, monopoly, oligopoly, asymmetric firms), consumers' preferences and participants' distribution set the scene for the literature about credence goods. As a result, the process seems like a domino game once a question is answered, a new one arises.

To begin with, several suggestions about the appropriate certificate for GM products such as labeling, Minimum Quality Standards (MQS)[5] and grading have been made. In the first case a label with containing or not is preferred, while in MQS a minimum level is imposed. Lastly, grading scales the goods according to GMO per

[4] Akerlof, G. A, (1970)

ingredient. Lapan and Moschini (2007) showed that a tight standard may lead to welfare loss, a label is more preferable for the firms and MQS may be misplaced if they are set by firms. Marette (2008) follows the same path and mentions that a standard imposed is quite differentiated by a label which can be set by the firm although it prefers without regulation. Specifically, the existence of a safety standard can cause the absence of a label or the appearance of it due to the circumstances. After choosing the type of quality standard - in our case it is the label – we have to decide the characteristics of the label.

Secondly, social planner confronts a very important and basic problem. She should define whether the label is voluntary or obligatory. On the one hand consumers generally desire further information. On the other hand producers would initially avoid the label and the cost of it. In case of credence goods Segerson (1999) mentions that even if the quality of such products is not easily detectable direct government intervention through regulation is not imperative. The threat of mandatory labels in combination with financial support can be enough in order for firms to undertake the labeling process. On the contrary, Mitrokostas and Petrakis argues that while total profits without regulation are less than total profits under government interference, but since total welfare is increased, then sooner or later "firms' endogenous choice is to engage in Corporate Social Responsibility" (WP 2008). On the contrary, Fulton and Giannakas (2004) states that firms have a tendency in cheating, so government has to monitor the labeling process. Thereby, if firms decide to cheat, then appropriate regulation is imposed.

Unexpectedly, the imposition of a label can come from another group. For instance, the high quality suppliers are definitely well off by the introduction of regulation. In fact according to Zago and Pick (2004) if firms have market power, then they can impose the label, although consumers may lose part of their welfare after a while. Therefore, government may not be the only one that aims at restoration of information.

Apart from this perspective there are some other aspects for the obligation of a label or not and they have no connection with government. Renck (2003) and Latvala and Kola (2003) converges in the same point and supports that labeling details can

[5] Instead of a label it can also set a MQS which does not give full information about the product but at least it restores somehow the informational asymmetry. Some papers referred to the subject are Garella and Petrakis (2007), Bonroy,O and Constantatos, C. (2004) and many others.

form a positive or a negative decision making in purchasing. Fulton and Giannakas (2004) believes that other important factors such as consumer's aversion, market power, marketing costs and last but not least the political power of each pressure group can enforce the obligatory label entry.

Another significant query is about the discretion or the continuity of the label. The choice out of two can lead to completely different results. When the label is continuous and voluntary, then it can cause no distortions. Contrarily, Roe and Sheldon (2007) argues that discretion can lead to problems such as the expulsion of good quality out of market. This statement was defined earlier when they conclude that continuous label improves consumer's surplus whereas binary is welfare improving for all groups assuming that the binary standard is higher than the one under continuous (Roe and Sheldon, 2001).

Last but not least we should decide who is going to provide the label. Nowadays according to regulation either government or private institutions certify firms. As a result the state should clarify whether it would intrude in the process or not. Some countries or federations found institutions in order to correct the lack of full information. International Standard Organisation (with ISO 9000) is an example of a private middle institution whereas the agricultural department of a country can be the public certifier. European labels (European Economic Community, 1992) include Protect Designation of Origin (PDO), Protected Geographical Indication (PGI) and the "Certificate of Specific Character" which reveals processing methods and specific characteristics. However, with the MacSharry reform of the Common Agricultural Policy (1992), the European Union reconsidered its agricultural policies, focusing on non - distortionary policy interventions. Since then there is a discussion about the identity of the label certifier. According to Crespi and Marette (2003) this decision had better be taken after the government considers factors such as the nature of product, the effect of the label in the market, the cost undertaker. They also mentions that in case of public label there should be a per-unit or an ad valorem fee. Mitrokostas and Petrakis (WP 2008) mentions that origin of label clearly depends on whether there will be a profit or a welfare maximizing problem and concludes that the social planner's approach is always preferable by society. In case of Baksi and Bose (2007) only when the ''market share effect'' greatly exceeds the ''incentive-to-cheat effect'', then label by a neutral part is the most preferable. Wolinsky (1993) claims that revelation can be achieved if there is competition in the market; therefore a

private institution is a better choice for the government. It is worthwhile mentioning that the label can be provided by the firm itself. Fulton and Giannakas (2004) states that an obligatory self – labeling sooner or later will lead to a mandatory label by a third party because firms have a natural tension in cheating and as a consequence government is obliged to establish a monitoring policy which is proved quite costly. However, present empirical studies[6] show that consumers believe that a public label is more trustworthy than a private and can easily restore asymmetric information.

Although the referred problems are the main, there are still many other queries that need an answer. For instance, if a label is chosen, which one is better: "Containing GMO or not containing?" Probably the answer lies on consumer's behavior. Crespi and Marette (2003) supports the same opinion: "The label «Does Contain» will be selected by a welfare maximizing government if there are many consumers who are reluctant to purchase products containing GMOs, while label «Does not Contain» will be chosen if that ratio is small".

The problem of labeling seems more complicated if we mention other countries as well. Bureau, Marette and Schiavina (1998) refers to the entry of low quality goods in the domestic market and how inefficiencies can be avoided. Nimon and Beghin (1999) focuses on the textile market and the effect of ecological labels. Roe and Sheldon (2001) finds out that if integration and harmonization of label through countries achieve, then welfare gain will be multiplied. In the case of trade there is great concern about the regulation in every country and how exporters can face possible changes in demand. Hooker (1999) analyses how the food safety regulation can be a trade barrier. Sheldon (2002) mentions that exporters may face the imposition of an obligatory label as a pre – entry approval.

Except for the above techniques, there are many ways in the credence market for revealing the fraudulent firms. An outstanding approach is the one of Emons' (2001). Emons claims that for unobservable or observable services and observable capacity is a sufficient condition for diagnosis instead of repair. However, he mentions that the kind of job is still important to find equilibrium. He also adds that prices in combination with capacity can be revealing (2005). Another prospect is advertisement. Mitrokostas and Petrakis support that advertising can give further information about the product but it can cause imbalance in the total welfare, whereas

[6] Latvala, T. and Kola, J. , (2003)

Liu (2006) proved that the market structure can help in the solution. Specifically, when the conscientious producers are more than the fraudulent ones, then this can reduce social welfare and efficiency.

All in all the general idea is that a label constitutes a reason to restore full information (sometimes even if it is not set into action and the threat is quite credible) and the aim of the present attempt is to contribute in this quest.

In this work market structure and efficiency is taken into account in a credence commodity market. The idea of the model sets its roots in the work of Bonroy and Constantatos (2003 and 2008) and Gabszewicz and Grilo (1992). The main difference with the last ones (Gabszewicz and Grilo, 1992) is the assumption of direct connection of high quality with high marginal cost and as a consequence the efficient supplier is the one with the bigger net surplus. In the present attempt there are two duopoly retailers and one upstream monopolist. The upper producer has an global view of the process and offers both the bad and the good quality. Consumers are homogeneous but there is a variance in their beliefs about the credibility of which is the high quality firm. Probability higher to ½ implies consumers' trustworthiness to this firm.

Eventually it appears to be a tendency of the low quality firm to avoid the installation of a regulatory mechanism. Its profits descend by the time that an introduction of a label has been done. On the contrary, the retailer with the good quality is interested in adopting a quality regulation since her profitability rises in this way. What is more interesting is that the upwards monopolist is indifferent whether there would be a dominancy of one or another firm without a label or efficiency with a label. Under some constraints the mentioned possibilities are more desirable than duopoly.

The paper is organized as follows: Section 2 presents the model and the analysis of the equilibrium prices. In Section 3 the imposition of a label is examined, whereas in last section some concluding remarks are providing.

The model

In the model there are three levels of participants: consumers, downstream retailers and upstream monopolist. Monopolist supplies to retailers and retailers provide to consumers. Additionally, in the market two different types of products can be found, the high quality (type 2) and the low quality (type 1). Each of the retailers exclusively sells the one or the other quality. It is assumed that the high quality requires greater cost to be produced, so as $c_1<c_2$ and that utility is higher than zero ($U_j>0$, j=1,2) in any case. Moreover, since that the high quality is the second one, it is definitely clear that $U_2> U_1$. Another hypothesis is that all consumers have the same preferences given by the function

$$V=U_j - p_j \qquad \forall V>0$$

where p_j is the price for every quality. If none good is purchased, then V=0.

In case that both goods are offered at the same price, good 2 is chosen. If both products are with different prices at market, then using the ratio $r = \frac{\Delta}{c_2 - c_1}$ for $\Delta = U_2 - U_1$ we can define that whether r>1, the product with the high quality is preferred and vice versa. Hereon, for r>1 the high quality and supplier 2 are the efficient ones.

Furthermore, consumer knows the existence of two qualities, the product characteristics, but she cannot realize which firm sells the high quality[7]. She is assumed to be characterized by a probability $\alpha \in [0, 1]$, which implies that when a is low, consumer is closer to the truth. Thereby, when probability tends to 1 then the final user believes that firm 1 sells the high quality product and the firm 2 the low one, which is completely misleading. Therefore, when $\alpha > \frac{1}{2}$, then consumer strongly believe that the firm 1 is the one that supplies the high quality and vice versa if $\alpha < \frac{1}{2}$. Another hypothesis is that there is a set of probabilities for consumer's distribution S= $[\underline{a}, \overline{a}]$, which are known to firms but unknown to final customers and their range is $0 \leq \underline{a} \leq \overline{a} \leq 1$. As a result the expected utility for every consumer will be

$$\alpha U_i + (1-\alpha)\, U_j - p_j \qquad \text{(for j=1,2)}$$

If we suppose that the prices are the same and the market is covered, then there is a consumer who will be indifferent whether to buy the one or the other good and whose belief is

$$a_n = \frac{1}{2} - \frac{p_2 - p_1}{2\Delta}$$

There is also a possibility of a market gap, which means that some of the consumers will not be attracted by any of the retailers. By bringing Hotelling model in mind this case implies an unexploited market share somewhere between the two goods. There will consequently be two indifferent clients: the one will be between buying good 1 or nothing and the other between buying good 2 or nothing.

$$a_1 = \frac{p_1 - U_1}{\Delta}$$

$$a_2 = \frac{U_2 - p_2}{\Delta}$$

Hence, with the appropriate manipulation it can be found out that the gap that appears in the market ends up to be more profitable for the high quality supplier. Profits of downstream and upstream are

$$\pi_1^u = \frac{\left(\overline{\alpha}\Delta + U_1\right)^2}{16\left(\overline{a} - \underline{a}\right)\Delta}$$

$$\pi_2^u = \frac{\left(-\underline{a}\Delta + U_2\right)^2}{16\left(\overline{a} - \underline{a}\right)\Delta}$$

$$\pi_m^u = \frac{\left(\overline{a}\Delta + U_1\right)^2 + \left(-\underline{a}\Delta + U_2\right)^2}{8\left(\overline{a} - \underline{a}\right)\Delta}$$

In case of $\overline{\alpha} + \underline{a} < 1$ and when the market is uncovered then firm 2 is benefited more than firm 1.

Proof:

$$\pi_1^u < \pi_2^u \Leftrightarrow$$
$$\left(\overline{\alpha}\Delta + U_1\right)^2 < \left(-\underline{a}\Delta + U_2\right)^2 \Leftrightarrow$$
$$\overline{\alpha} + \underline{a} < 1$$

[7] The uncertainty will lead consumers to decide according to their beliefs. Probabilities will form the results

Where $\overline{\alpha}\Delta + U_1 > 0$ and $-\underline{a}\Delta + U_2 > 0$ are two of the assumptions for the positive c_1 and c_2. The $\overline{\alpha} + \underline{a} < 1$ reveals consumers' beliefs which are closer to the truth or at least they are closer to the truth about the quality of one of the goods.

Further analysis needs the covered market case where there is a more perplexing connection between all levels and all firms. In equilibrium market can be dominated by one of the two firms depending which one is the efficient or otherwise there is a duopoly. Therefore, the demand is $D_1 = \max\{\frac{\overline{a} - a_m}{\overline{a} - \underline{a}}, 0\}$ and $D_2 = \max\{\frac{a_m - \underline{a}}{\overline{a} - \underline{a}}, 0\}$. If $\alpha_m \notin S$, then sales of the one firm disappear and the other rules all. The dominant firm sets price above marginal cost in order not to incur loss and so as to eliminate its competitor's profits. Moreover, full information restores the dominance of the efficient downstream supplier whereas incomplete information preserves consumers' beliefs. As a matter of fact if $\overline{a} < \frac{1}{2}(1 - \frac{1}{r})$, then firm 2 is the dominant firm and if $\underline{a} > \frac{1}{2}(1 - \frac{1}{r})$ then firm 1 master the whole demand for this good. The mastership of one retailer is not necessarily more preferable in equilibrium than duopoly. Moreover, a necessary and sufficient condition for this is that $D_1 > 0$, which means that it should be $\overline{a} > \frac{1}{2}\left[\underline{a} + \frac{1}{2}\left(1 - \frac{1}{r}\right)\right] \equiv f(\underline{a})$ and $\overline{a} > 2\underline{a} - \frac{1}{2}\left(1 + \frac{1}{r}\right) \equiv g(\underline{a})$.

Therefore, if the low quality is the efficient one, then $r \in [0, 1]$ and firm 1 possesses a monopolistic market share and firm 2 is expelled by the market or may have a limited clientele. In this occasion the low quality firm may even charge higher price just to have access to consumers with the lower elasticity. On the other hand, when high quality is the efficient, which follows the $r \in [1, \infty]$, there is a chance that firm 2 may or may not be dominant even if its quality has been revealed.

Taking into account the upstream monopolist we can easily discover that her profits alter according to the changes that are done to the downwards level. Providing that firm 1 is the dominant then its profits are defined to $\pi_m^{d1} = c_1$. Otherwise in case

that firm 2 is dominant then the profits are going to be $\pi_m^{d2} = c_2$. If we compare the two options, then the incentive for the upstream supplier will be greater to support a dominance of the second firm since $c_2 > c_1$, which has been stated by the very beginning. This could cause a distortion in the market if the upper monopolist could choose her clients. However, there is also a possibility that the downstream firms would compete under oligopolistic terms and they reveal a different image of the market.

Considering that rivalrous conditions are set, then duopolists share profits from a two stage game by using backwards induction. Under these conditions market share is differentiated. What is really interesting is the fact that despite the downwards duopoly, there is an upwards monopoly. This implies that the upstream supplier is the same and for this reason there may be a distorting impact in the market.

Thus, the market structure in combination with the kind of the two demand functions raises queries. Specifically, the maximization of the monopolist profit function leads to two mirror images equations. In this point another equation should be taken into account. The first order conditions of profit optimization are not enough. The firm considers that the indifferent consumer should not only equalize the expected utility between the two products but also should not have net surplus, which implies that $EU\left(a_n\right) = 0$. The results lead to

$$c_1 = \frac{1}{12}\left(-\frac{1+2(\overline{a}-2\underline{a})}{\overline{a}-\underline{a}} + 12U_2 - 6(1+2\overline{a}-2\underline{a})\Delta\right)$$

and

$$c_2 = \frac{1}{12}\left(4+\frac{1-2\overline{a}}{\overline{a}-\underline{a}} + 12U_2 - 6(1+2\overline{a}-2\underline{a})\Delta\right)$$

And they stand if and only if $\overline{a} > 2\underline{a}$ .Since c_1 and c_2 are set then the results for the other equation can be easily defined.

$$p_1 = \frac{1}{36(\overline{\alpha}-\underline{\alpha})}\left(-1+\overline{\alpha}(-2+36U_2-30\Delta)+12\overline{\alpha}^2\Delta - 12\underline{\alpha}^2\Delta + \underline{\alpha}(4-36U_2+30\Delta)\right)$$

$$p_2 = \frac{1}{36(\overline{\alpha}-\underline{\alpha})}\left(-1+\overline{\alpha}(2+36U_2-6\Delta)-12\overline{\alpha}^2\Delta + 12\underline{\alpha}^2\Delta + \underline{\alpha}(-4-36U_2+6\Delta)\right)$$

$$D_1 = \frac{1}{36}\Delta(1 + 24\bar{a}^2\Delta + 12\underline{\alpha}^2\Delta + \underline{\alpha}(6\Delta - 4) + \bar{\alpha}(2 - 6(1 + 6\underline{\alpha})\Delta))$$

$$D_2 = \frac{1}{36}\Delta(1 + 2\bar{\alpha} - 4\underline{\alpha})(-1 + 6\bar{\alpha}\Delta - 6\underline{\alpha}\Delta)$$

$$\pi_1 = \frac{\Delta}{648(\bar{\alpha} - \underline{\alpha})}(1 + 24\bar{\alpha}^2\Delta + 12\underline{\alpha}^2\Delta + \underline{\alpha}(-4 + 6\Delta) + \bar{\alpha}(2 - 6(1 + 6\underline{\alpha})\Delta))^2$$

$$\pi_2 = \frac{\Delta}{648(\bar{\alpha} - \underline{\alpha})}(1 + 2\bar{\alpha} - 4\underline{\alpha})^2(1 - 6\bar{\alpha}\Delta + 6\underline{\alpha}\Delta)^2$$

$$\pi_m = \frac{\Delta}{216(\bar{\alpha} - \underline{\alpha})}(-(1 + 2\bar{\alpha} - 4\underline{\alpha})^2 + 6(\bar{\alpha} - \underline{\alpha})(1 + \bar{\alpha} - 2\bar{\alpha}^2 - 5\underline{\alpha} + 2\bar{\alpha}\underline{\alpha} + 4\underline{\alpha}^2 + 36(\bar{\alpha} - \underline{\alpha})^2 U_2)\Delta - 108(1 + 2\bar{\alpha} - 2\underline{\alpha})(\bar{\alpha} - \underline{\alpha})^3\Delta^2)$$

Moreover, there are some constraints that should be set for the existence of the above. These are mainly referred to the positive sign of p_1 and p_2 and the demand functions.

$$p_1 \geq 0 \Rightarrow \bar{a} \geq \frac{1}{2}\left[\underline{a} + \frac{1}{2}\left(1 - \frac{1}{r} - \frac{3c_1}{\Delta}\right)\right] \equiv k\left(\underline{a}, c_1\right)$$

$$p_2 \geq 0 \Rightarrow \bar{a} \geq 2\underline{a} - \frac{1}{2}\left(1 + \frac{2}{r} + \frac{3c_1}{\Delta}\right) \equiv y\left(\underline{a, c_1}\right)$$

$$D_1 > 0 \Rightarrow \bar{a} > \frac{1}{2}\left[\underline{a} + \frac{1}{2}\left(1 - \frac{1}{r}\right)\right] \equiv f\left(\underline{a}\right)$$

$$D_2 > 0 \Rightarrow \bar{a} > 2\underline{a} - \frac{1}{2}\left(1 + \frac{1}{r}\right) \equiv g\left(\underline{a}\right)$$

$$U_2 > \frac{\Delta}{2}$$

The combination of $f(\underline{a})$, $g(\underline{a})$ and 45° line is a way to define the area of $\underline{a}$ and $\underline{a}$ in case of a duopoly or monopoly in retailers market. The intersection of the red and green line (the equation of $f(\underline{a})$ and $g(\underline{a})$) defines four different situations. The upper left part from the intersection is the case of a duopoly. The upper right part is when firm 2 is out of the market. The lower right part is when firm 2 is dominant and the lower left part is when there is no firm in the market. It is clear that the lower the r the wider the range of $\overline{\alpha}$ and $\underline{\alpha}$. When the r$\in$[0,1], the $\overline{\alpha}$ and $\underline{\alpha}$ take prices from almost 0 to 1(Figure 1). The efficiency of firm 1 can cause bigger uncertainty for consumers about the quality of each group, because the distribution of probabilities is greater. On the other hand, when firm 2 is the efficient, then the range of probabilities (so as duopoly to exist) is getting smaller (Figures 2, 3, 4). Specifically, for r =100 (Figure 4) the S set has shrunk. The problem is that if the probability set is between the green and purple line (upper left polygon), then consumers are incorrect about the origin of each good. Moreover, between the red and the purple line there is duopoly and the consumers are getting closer to the truth.

A possible comparison between duopoly and dominancy for the upstream monopolist will show that in case that

$$\overline{\alpha} > 2\underline{\alpha} - \frac{1}{2} \quad and \quad \left(1 + 2\overline{\alpha} - 4\underline{\alpha} + 6\left(1 + 4\overline{\alpha} - 2\underline{\alpha}\right)\left(\overline{a} - \underline{a}\right)\Delta\right) > 0 \Leftrightarrow \overline{\alpha} > \frac{\underline{\alpha}}{2} - \frac{1}{4}$$

then there is a greater tendency to support monopoly market. Otherwise, the profitable case can be proved avoidable and a competitive market can give the desired satisfaction. The upstream supplier will react in the same way if there is a label to be imposed. The reason is that the profits in this production level are the same in retailer's dominancy and a full information case, in which result we will be leaded after the analysis of the downwards firms.

Perfect Label

A traditional approach would fulfill its target as soon as she would find the equilibrium point. Under these circumstances this seems quite inadequate. Consumers speculate about the quality of each product and the way of restoration of information.

In this case a private or public institution takes charge of this process. The origin of such an organization is beyond the boarder of the present attempt. Taking it as granted the analysis focuses on the existence of a perfect label. A full information situation means that beliefs for high and low quality vanish, which means that $\overline{\alpha} = \underline{\alpha} = 0$. Besides, the label can be voluntary or mandatory. In fact, even if it is optional the high quality firm has always a motive to test its goods, so as to reveal its quality and cream consumers with a higher mark up.

Consequently, the entry of a label resets the scene. The efficiency of each firm is an important element, which differentiates the prices and the profits given the last time. As a matter of fact the results are clear below.

Efficient firm	π_1^{PL}	π_2^{PL}	π_m^{PL}
1	$c_2 - c_1 - \Delta$	0	c_1
2	0	$\Delta - (c_2 - c_1)$	c_2

In addition, a comparison between a non – label case and a label one can lead to interesting conclusions. Specifically, firm one has greater profits under dominance or duopoly without a label than with a label, which implies that a low quality firm has great incentives to avoid the introduction of a certifier. As a consequence this reaction more or less reveals the type of the retailer and the possibility of label entry can be fated for its survival. On the contrary, firm two has quite dissimilar outcomes. Hereon the high quality company clearly prefers the installation of a quality certification to the dominancy if it is the efficient one. This is a logical consequence respectively to the one of the previous retailer.

Ascending to the production level the upstream monopolist reveals interesting results. Strange as it may seem she tastes the same profit under non – label monopoly and perfect label. This may show indifference in preference. Between dominancy without a label and imposition of it she bears the same fruits. However, there is a possible incentive for avoiding the label especially if there will be an extra fixed cost but this would need further investigation to be said in certainty. Considering that the follow constraints stand

$$\overline{\alpha} > 2\underline{\alpha} - \frac{1}{2} \quad and \quad \left(1 + 2\overline{\alpha} - 4\underline{\alpha} + 6\left(1 + 4\overline{\alpha} - 2\underline{\alpha}\right)\left(\overline{a} - \underline{a}\right)\Delta\right) > 0 \Leftrightarrow \overline{\alpha} > \frac{\underline{\alpha}}{2} - \frac{1}{4}$$

which means that $\overline{\alpha} > 2\underline{\alpha} - \frac{1}{2}$ is a sufficient conditions then duopoly case leads to inferior profits than a case under full information and as a result she would understand that providing only with superior quality goods the market can be a quite gainful movement.

Conclusion

The existence of uncertainty in a good market reveals that consumers need additional information to form their purchasing decision. This would be easily done if it was not for credence goods market, where traditional reputation is out of effect. The interesting part arises when the introduction of a perfect label comes to restore the informational shortage. Then the scene is reset and different preferences become obvious.

For the retailer of the low quality good this news is fateful. The reveal of her quality without considering the efficiency part is a fact that it will decrease the profits. This is true for duopoly or monopoly in the retailers' market. As a result firm 1 is not satisfied by the introduction of a label. On the opposite site the high quality company faces with excitement a full informed market. The introduction of a label raises its profits in case of a duopoly. If the profits are compared to duopoly profits, then the result is ambiguous.

The analysis of the upstream monopolist is quite surprising. She prefers equally firm 1 to be dominant or firm 1 to be efficient with a label. The same stands for firm 2. The interesting part is that if upstream monopolist can choose whether to supply on or the other firm, then there can be a distortion to the market, because her profits are higher when firm 2 dominates the market. The case of a duopoly can be more or less profitable according to the constraints. Finally, if the upwards monopolist supplies high quality good to the second firm then even the second would be highly benefited as long as she is the efficient one.

If the low quality firm is efficient, consumers have a wider distribution in their beliefs. On the contrary, the efficiency of firm 2 gets smaller the probabilities' set. Under some circumstances they can purchase goods and they can be aware of the quality or at least they can be closer to the truth. Consumers can approach real quality of each firm under duopoly or dominancy of firm 2. This is not difficult to happen if the upstream monopolists can decide to provide with goods both firms or just firm 2. Lastly, when a perfect label is imposed, there is informational restoration and probabilities of beliefs become zero.

Acknowledgements

I would like to express my gratitude to Mr. Constantatos not only for everything that he has taught to me, but for his useful comments during this attempt as well. Also, I thank my family and Charis for their patience and understanding during this period.

FIGURES

- Vertical axis : $\overline{\alpha}$

  Horizontal axis: $\underline{\alpha}$
- Blue line: $\overline{\alpha} = \underline{\alpha}$

  Red line: $f(\underline{a})$

  Green line: $g(\underline{a})$

  Purple line: $\overline{\alpha} = 0.5$

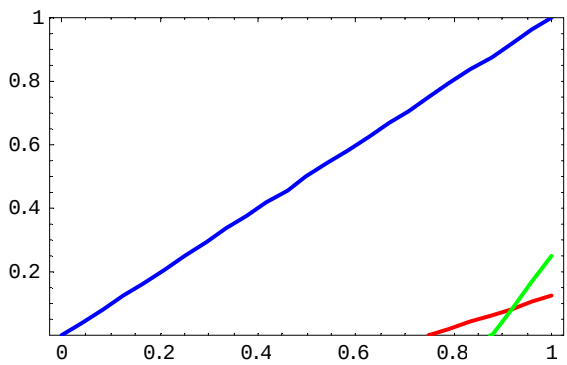

Figure 1: For r=0.4

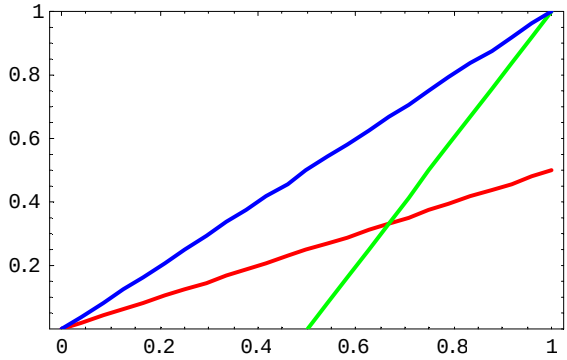

Figure 2: For r=1

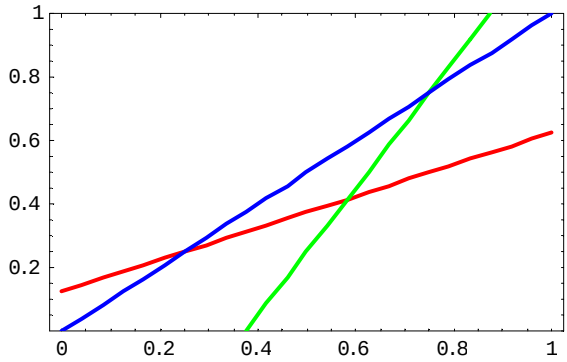

Figure 3: For r=2

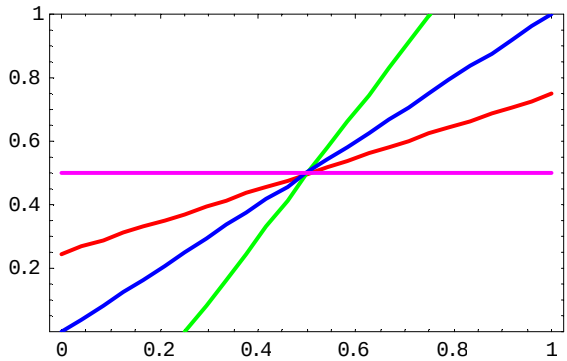

Figure 4: For r=100

APPENDIX

- Without label

UNCOVERED MARKET

The consumer 1 is indifferent in buying the good 1 or not

$$\begin{aligned} & a_1 U_2 + (1-a_1)U_1 - p_1 = 0 \Leftrightarrow \\ & a_1(U_2 - U_1) + U_1 = p_1 \Leftrightarrow \\ & a_1 = \frac{p_1 - U_1}{\Delta} \end{aligned} \tag{1.1}$$

Where

$$\Delta = \mathrm{U}_2 - \mathrm{U}_1 \tag{1.2}$$

and the indifference between good 2 and non purchasing is

$$\begin{aligned} & a_2 U_1 + (1-a_2)U_2 - p_2 = 0 \Leftrightarrow \\ & U_2 + a_2(U_2 - U_1) = p_2 \Leftrightarrow \\ & a_2 = \frac{U_2 - p_2}{\Delta} \end{aligned} \tag{1.3}$$

<u>Constraints in case of uncovered market</u>

If

$$\begin{aligned} & a_1 > a_m \Rightarrow \\ & \frac{p_1 - U_1}{\Delta} > \frac{1}{2} - \frac{p_2 - p_1}{2\Delta} \Rightarrow \\ & p_1 + p_2 > U_2 + U_1 \end{aligned} \tag{1.4}$$

The same result arise if

$$a_2 < a_m \Rightarrow$$
$$\frac{U_2 - p_2}{\Delta} < \frac{1}{2} - \frac{p_2 - p_1}{2\Delta} \Rightarrow \tag{1.5}$$
$$p_1 + p_2 > U_2 + U_1$$

In this case substituting (1.1) into the demand function for the low quality good this will be

$$D_1^u = \frac{\bar{a} - a_1}{\bar{a} - \underline{a}} \Leftrightarrow$$
$$D_1^u = \frac{\bar{a} - \frac{p_1 - U_1}{\Delta}}{\bar{a} - \underline{a}} \Leftrightarrow \tag{1.6}$$
$$D_1^u = \frac{\bar{a}\Delta - p_1 + U_1}{\left(\bar{a} - \underline{a}\right)\Delta}$$

So $$U_1 - p_1 + \bar{a}\Delta > 0 \tag{1.7}$$

Equally substituting (1.3) into the D_2

$$D_2^u = \frac{a_2 - \underline{a}}{\bar{a} - \underline{a}} \Leftrightarrow$$
$$D_2^u = \frac{-\underline{a} - \frac{p_2 - U_1}{\Delta}}{\bar{a} - \underline{a}} \Leftrightarrow \tag{1.8}$$
$$D_2^u = \frac{U_2 - p_2 - \underline{a}\Delta}{\left(\bar{a} - \underline{a}\right)\Delta}$$

Since

$$U_2 - p_2 - \underline{a}\Delta > 0 \tag{1.9}$$

As a consequence profits will be for downstream retailers by using (1.6) and (1.8)

$$\pi_1^u = \left(p_1 - c_1\right)\left(\frac{\bar{a}\Delta - p_1 + U_1}{\left(\bar{a} - \underline{a}\right)\Delta}\right) \tag{1.10}$$

and

$$\pi_2^u = \left(p_2 - c_2\right)\left(\frac{U_2 - p_2 - \underline{a}\Delta}{\left(\bar{a} - \underline{a}\right)\Delta}\right) \tag{1.11}$$

Maximizing (1.10) and (1.11) we obtain

$$p_1^u = \frac{\bar{a}\Delta + U_1 + c_1}{2} \tag{1.12}$$

and

$$p_2^u = \frac{-\underline{a}\Delta + U_2 + c_2}{2} \tag{1.13}$$

Moreover it should be checked whether profit functions follow the property of convexity in p_i

$$\frac{\partial^2 \pi_i^u}{\partial^2 p_i^u} = -\frac{2}{\left(\bar{a} - \underline{a}\right)\Delta} < 0 \tag{1.14}$$

for i=1,2

Setting (1.12) and (1.13) into (1.6) and (1.8) it can easily be found that

$$D_1^u = \frac{\bar{a}\Delta + U_1 - c_1}{2\left(\bar{a} - \underline{a}\right)\Delta} \tag{1.15}$$

and

$$D_2^u = \frac{-\underline{a}\Delta + U_2 - c_2}{\left(\bar{a} - \underline{a}\right)\Delta} \tag{1.16}$$

Using these final demand functions the profits of the manufacturer will be

$$\pi_m^u = c_1 D_1 + c_2 D_2 \Rightarrow$$
$$\pi_m^u = c_1\left(\frac{\bar{a}\Delta + U_1 - c_1}{2\left(a - a\right)\Delta}\right) + c_2\left(\frac{-\underline{a}\Delta + U_2 - c_2}{2\left(a - a\right)\Delta}\right)$$

If it is differentiated with respect to c_1 and c_2 then

$$c_1^{\ u} = \frac{\bar{a}\Delta + U_1}{2} \tag{1.17}$$

and

$$c_2^{\ u} = \frac{-\underline{a}\Delta + U_2}{2} \tag{1.18}$$

It is clear that

$$\begin{aligned} &\bar{a}\Delta - U_1 > 0 \Leftrightarrow \\ &\bar{a}U_2 - \left(\bar{a} - 1\right)U_1 > 0 \end{aligned} \tag{1.19}$$

and

$$\begin{aligned} &-\underline{a}\Delta + U_2 > 0 \Leftrightarrow \\ &\left(1 - \underline{a}\right)U_2 + \underline{a}U_1 > 0 \end{aligned} \tag{1.20}$$

Furthermore, the second order conditions are important

$$\frac{\partial^2 \pi_m^u}{\partial^2 c_i} = -\frac{2}{\left(\bar{a} - \underline{a}\right)\Delta} < 0 \tag{1.21}$$

for i=1,2

Finally, the profits of the upstream and downstream firm will be

$$\pi_1^u = \frac{\left(\bar{\alpha}\Delta + U_1\right)^2}{16\left(\bar{a} - \underline{a}\right)\Delta} \tag{1.22}$$

$$\pi_2^u = \frac{\left(-\underline{a}\Delta + U_2\right)^2}{16\left(\bar{a} - \underline{a}\right)\Delta} \tag{1.23}$$

$$\pi_m^u = \frac{\left(\bar{a}\Delta + U_1\right)^2 + \left(-\underline{a}\Delta + U_2\right)^2}{8\left(\bar{a} - \underline{a}\right)\Delta} \tag{1.24}$$

Comparing the π_1^u and π_2^u

$$\begin{aligned}
&\pi_1^u < \pi_2^u \Leftrightarrow \\
&\left(\overline{\alpha}\Delta + U_1\right)^2 < \left(-\underline{a}\Delta + U_2\right)^2 \Leftrightarrow \\
&U_1 < U_2
\end{aligned} \tag{1.25}$$

COVERED MARKET

In this case the indifferent consumer is the one who shows the same preference between buying the good 1 or 2 which means that

$$\left.\begin{aligned} EU_1 &= aU_2 + (1-a)U_1 - p_1 \\ EU_2 &= aU_1 + (1-a)U_2 - p_2 \end{aligned}\right\} \Leftrightarrow EU_1 = EU_2$$

So if $\Delta = U_2 - U_1$

$$\begin{aligned}
&EU_1 = EU_2 \Leftrightarrow \\
&p_1 - p_2 = U_1\left(1-2a_n\right) - U_2\left(1-2a_n\right) \Leftrightarrow \\
&a_n = \frac{1}{2} - \frac{p_2 - p_1}{2\Delta}
\end{aligned} \tag{2.1}$$

<u>Constraints</u>

i. If

$$\begin{aligned}
&a_n \geq \overline{a} \Leftrightarrow \\
&\frac{1}{2} - \frac{p_2 - p_1}{2\Delta} \geq \overline{\alpha} \Leftrightarrow \\
&\underbrace{p_2 \leq p_1 - \left(2\overline{a} - 1\right)\Delta}_{\text{then}}
\end{aligned} \tag{2.2}$$

$D_1=0$
$D_2=1$

ii. If

$$\underbrace{\begin{aligned} & a_n \le \underline{a} \Leftrightarrow \\ & \frac{1}{2} - \frac{p_2 - p_1}{2\Delta} \le \underline{a} \Leftrightarrow \\ & p_2 \ge p_1 - \left(2\underline{a} - 1\right)\Delta \end{aligned}}_{\text{then}} \tag{2.3}$$

$D_1=1$
$D_2=0$

iii. If

$$\underbrace{\begin{aligned} & \underline{a} \le a_n \le \overline{a} \Leftrightarrow \\ & p_1 - \left(2\overline{a} - 1\right)\Delta \le p_2 \le p_1 - \left(2\underline{a} - 1\right)\Delta \end{aligned}}_{\text{then}} \tag{2.4}$$

$$D_1 = \frac{\overline{a} - 1/2}{\overline{a} - \underline{a}} + \frac{p_2 - p_1}{2\left(\overline{a} - \underline{a}\right)\Delta} \tag{2.5}$$

and

$$D_2 = \frac{1/2 - \underline{a}}{\overline{a} - \underline{a}} - \frac{p_2 - p_1}{2\left(\overline{a} - \underline{a}\right)\Delta} \tag{2.6}$$

- *Downstream monopoly*

If only firm 1 survives

$$\pi_1^{d1} = \left(2\underline{a} - 1\right)\Delta + c_2 - c_1 \tag{2.7}$$

and upstream monopolist's profits are

$$\pi_m^{d1} = c_1 \tag{2.8}$$

If only firm 2 survives

$$\pi_2^{d2} = \left(1 - 2\bar{a}\right)\Delta + c_1 - c_2 \qquad (2.9)$$

and

$$\pi_m^{d2} = c_2 \qquad (2.10)$$

Synoptically

Dominant firm	π_1^{di}, π_2^{di} (i=1,2)	π_m^{di} (i=1,2)	Constraints
1	$\left(2\underline{a} - 1\right)\Delta + c_2 - c_1$, 0	c_1	$p_1^{d1} > \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta}{3} + \frac{c_2 + 2c_1}{3}$
2	0, $\left(1 - 2\bar{a}\right)\Delta + c_1 - c_2$	c_2	$p_2^{d2} > \frac{\left[2\left(\bar{a} - 2\underline{a}\right) + 1\right]\Delta}{3} + \frac{2c_2 + c_1}{3}$

- *Duopoly*

Retailers' profits

The profits for the firm producing the low quality will be

$$\pi_1 = \left(p_1 - c_1\right)\left(\frac{\bar{a} - 1/2}{\bar{a} - \underline{a}} + \frac{p_2 - p_1}{2\left(\bar{a} - \underline{a}\right)\Delta}\right) \qquad (2.11)$$

Similarly for the firm 2, the one with the high quality

$$\pi_2 = \left(p_2 - c_2\right)\left(\frac{1/2 - \underline{a}}{\bar{a} - \underline{a}} - \frac{p_2 - p_1}{2\left(\bar{a} - \underline{a}\right)\Delta}\right) \qquad (2.12)$$

Differentiating (2.11) with respect to p_1 and (2.12) to p_2

$$\frac{\partial \pi_1}{\partial p_1} = 0 \Rightarrow$$

$$\frac{\bar{a} - 1/2}{\bar{a} - \underline{a}} + \frac{p_2 - 2p_1}{2\left(\bar{a} - \underline{a}\right)\Delta} + \frac{c_1}{2\left(\bar{a} - \underline{a}\right)\Delta} = 0 \Rightarrow$$

$$p_1 = \left(\bar{a} - \frac{1}{2}\right)\Delta + \frac{p_2}{2} + \frac{c_1}{2} \tag{2.13}$$

and

$$\frac{\partial \pi_2}{\partial p_2} = 0 \Rightarrow$$

$$\frac{1/2 - \underline{a}}{\bar{a} - \underline{a}} + \frac{p_1 - 2p_2}{2\left(\bar{a} - \underline{a}\right)\Delta} + \frac{c_2}{2\left(\bar{a} - \underline{a}\right)\Delta} = 0 \Rightarrow$$

$$p_2 = \left(\frac{1}{2} - \underline{a}\right)\Delta + \frac{p_1}{2} + \frac{c_2}{2} \tag{2.14}$$

If the two reaction functions are solved together

$$p_1 = \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta}{3} + \frac{c_2 + 2c_1}{3} \tag{2.15}$$

$$p_2 = \frac{\left[2\left(\bar{a} - 2\underline{a}\right) + 1\right]\Delta}{3} + \frac{2c_2 + c_1}{3} \tag{2.16}$$

The above expressions should not be negative which means that

$$\begin{aligned} p_1 &= \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta}{3} + \frac{c_2 + 2c_1}{3} \geq 0 \Rightarrow \\ \bar{a} &\geq \frac{1}{2}\left[\underline{a} + \frac{1}{2}\left(1 - \frac{1}{r} - \frac{3c_1}{\Delta}\right)\right] \equiv k\left(\underline{a}, c_1\right) \end{aligned} \tag{2.17}$$

$$\begin{aligned} p_2 &= \frac{\left[2\left(\bar{a} - 2\underline{a}\right) + 1\right]\Delta}{3} + \frac{2c_2 + c_1}{3} \geq 0 \Rightarrow \\ \bar{a} &\geq 2\underline{a} - \frac{1}{2}\left(1 + \frac{2}{r} + \frac{3c_1}{\Delta}\right) \equiv y\left(\underline{a}, c_1\right) \end{aligned} \tag{2.18}$$

Using (2.15) and (2.16) into (2.5) and (2.6) the new D_1 and D_2 will depend on c_1, c_2, $\bar{a}$ and $\underline{a}$

$$D_1 = \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta + c_2 - c_1}{6\left(\bar{a} - \underline{a}\right)\Delta} \tag{2.19}$$

$$D_2 = \frac{\left[2\left(\bar{a} - \underline{2a}\right) + 1\right]\Delta + c_1 - c_2}{6\left(\bar{a} - \underline{a}\right)\Delta} \tag{2.20}$$

A necessary condition for $D_1>0$ to be positive is

$$\begin{aligned} D_1 &= \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta + c_2 - c_1}{6\left(\bar{a} - \underline{a}\right)\Delta} > 0 \Rightarrow \\ \bar{a} &> \frac{1}{2}\left[\underline{a} + \frac{1}{2}\left(1 - \frac{1}{r}\right)\right] \equiv f\left(\underline{a}\right) \end{aligned} \tag{2.21}$$

and for $D_2>0$ is

$$\begin{aligned} D_2 &= \frac{\left[2\left(\bar{a} - \underline{2a}\right) + 1\right]\Delta + c_1 - c_2}{6\left(\bar{a} - \underline{a}\right)\Delta} > 0 \Rightarrow \\ \bar{a} &> 2\underline{a} - \frac{1}{2}\left(1 + \frac{1}{r}\right) \equiv g\left(\underline{a}\right) \end{aligned} \tag{2.22}$$

Finally by replacing (2.19) and (2.20) into (2.11) and (2.12) retailers' profits will be

$$\pi_1 = 2\left(\bar{\alpha} - \underline{\alpha}\right) D_1^2 \tag{2.23}$$

$$\pi_2 = 2\left(\bar{\alpha} - \underline{\alpha}\right) D_2^2 \tag{2.24}$$

- <u>Manufacturer's profits</u>

Supposing there is a manufacturer in the market that provides the inputs to two firms. Then his profit will be

$$\pi_m = c_1 D_1 + c_2 D_2 \Leftrightarrow$$

$$\pi_m = c_1 \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta + c_2 - c_1}{6\left(\bar{a} - \underline{a}\right)\Delta} + c_2 \frac{\left[2\left(\bar{a} - \underline{2a}\right) + 1\right]\Delta + c_1 - c_2}{6\left(\bar{a} - \underline{a}\right)\Delta} \tag{2.25}$$

Maximizing (2.25) with respect to c_1 and c_2 the first order conditions that appear are

$$c_1 = \frac{\left[2\left(2\bar{a} - \underline{a}\right) - 1\right]\Delta}{6\left(\bar{a} - \underline{a}\right)\Delta} + c_2 \tag{2.26}$$

$$c_2 = \frac{\left[2\left(\bar{a} - \underline{2a}\right) + 1\right]\Delta}{6\left(\bar{a} - \underline{a}\right)\Delta} + c_1 \tag{2.27}$$

Unfortunately these two relations are mirror images, so it is inevitable a specific solution to be found. As a consequence for the identification of c_1 and c_2 it is worthwhile mentioning that there is an extra equation that should not be overlooked. There is no reason for the producer to leave any extra surplus even to the indifferent consumer, which implies that

$$EU\left(a_n\right) = 0 \tag{2.28}$$

First of all for defining α_n as a function of c_1 and c_2 we should substitute (2.15) and (2.16) into (2.1)

$$a_n = \frac{5\Delta - 2\left(\bar{a} + \underline{a}\right)\Delta - c_1 + c_2}{6\Delta} \tag{2.29}$$

If (2.29) and (2.15) is replaced in (2.28), then

$$U_2 - \left(\frac{5\Delta - 2\left(\bar{a} + \underline{a}\right)\Delta - c_1 + c_2}{6\Delta}\right)\Delta - \left(\frac{2\left(2\bar{a} - \underline{a}\right)}{3}\right)\Delta - \frac{c_2}{3} - \frac{2c_1}{3} = 0$$

which can be solved with respect to c_2

$$c_2 = -c_1 + 2U_2 - \Delta - 2\bar{\alpha}\Delta + 2\underline{\alpha}\Delta \tag{2.30}$$

As defined $c_2>0$

$$2U_2 - \Delta - 2\bar{\alpha}\Delta + 2\underline{\alpha}\Delta > c_1 \tag{2.31}$$

Solving (2.30) and (2.27) we can get

$$c_1 = \frac{1}{12}\left(-\frac{1 + 2(\bar{a} - 2\underline{a})}{\bar{a} - \underline{a}} + 12U_2 - 6(1 + 2\bar{a} - 2\underline{a})\Delta\right) \tag{2.32}$$

$$c_2 = \frac{1}{12}(4 + \frac{1-2\overline{a}}{\overline{a}-\underline{a}} + 12U_2 - 6(1+2\overline{a}-2\underline{a})\Delta) \tag{2.33}$$

There is also a main hypothesis that $c_2 > c_1$ which by using (2.32) and (2.33) leads to

$$\begin{aligned} &\frac{1+2\overline{a}-4\underline{a}}{-(\overline{a}-\underline{a})} < 0 \Leftrightarrow \\ &\overline{a} > 2\underline{a} \end{aligned} \tag{2.34}$$

For known c_1 and c_2 then

$$\begin{aligned} p_1 = \frac{1}{36(\overline{\alpha}-\underline{\alpha})}(&-1+\overline{\alpha}(-2+36U_2-30\Delta)+12\overline{\alpha}^2\Delta - \\ &12\underline{\alpha}^2\Delta + \underline{\alpha}(4-36U_2+30\Delta)) \end{aligned} \tag{2.35}$$

$$\begin{aligned} p_2 = \frac{1}{36(\overline{\alpha}-\underline{\alpha})}(&-1+\overline{\alpha}(2+36U_2-6\Delta)-12\overline{\alpha}^2\Delta + \\ &12\underline{\alpha}^2\Delta + \underline{\alpha}(-4-36U_2+6\Delta)) \end{aligned} \tag{2.36}$$

$$\begin{aligned} D_1 = \frac{1}{36}\Delta(&1+24\overline{a}^2\Delta+12\underline{\alpha}^2\Delta+\underline{\alpha}(6\Delta-4)+ \\ &\overline{\alpha}(2-6(1+6\underline{\alpha})\Delta)) \end{aligned} \tag{2.37}$$

$$D_2 = \frac{1}{36}\Delta(1+2\overline{\alpha}-4\underline{\alpha})(-1+6\overline{\alpha}\Delta-6\underline{\alpha}\Delta) \tag{2.38}$$

$$\begin{aligned} \pi_1 = \frac{\Delta}{648(\overline{\alpha}-\underline{\alpha})}(&1+24\overline{\alpha}^2\Delta+12\underline{\alpha}^2\Delta+\underline{\alpha}(-4+6\Delta)+ \\ &\overline{\alpha}(2-6(1+6\underline{\alpha})\Delta))^2 \end{aligned} \tag{2.39}$$

$$\pi_2 = \frac{\Delta}{648(\overline{\alpha}-\underline{\alpha})}(1+2\overline{\alpha}-4\underline{\alpha})^2(1-6\overline{\alpha}\Delta+6\underline{\alpha}\Delta)^2 \tag{2.40}$$

$$\pi_m = \frac{\Delta}{216(\overline{\alpha}-\underline{\alpha})}(-(1+2\overline{\alpha}-4\underline{\alpha})^2 + 6(\overline{\alpha}-\underline{\alpha})(1+\overline{\alpha}-2\overline{\alpha}^2-5\underline{\alpha}+2\overline{\alpha}\underline{\alpha}+4\underline{\alpha}^2 + 36(\overline{\alpha}-\underline{\alpha})^2 U_2)\Delta - 108(1+2\overline{\alpha}-2\underline{\alpha})(\overline{\alpha}-\underline{\alpha})^3\Delta^2) \quad (2.41)$$

Further constraints arise such as $p_1 > 0$ and $p_2 > 0$ (by using (2.35) and (2.36))

$$4\underline{\alpha} + 36\overline{\alpha}U_2 + 6(\overline{\alpha}-\underline{\alpha})(-5+2\overline{\alpha}+2\underline{\alpha})\Delta > 1+2\overline{\alpha}+36\underline{\alpha}U_2 \quad (2.42)$$

$$1+2\overline{\alpha}+36\overline{\alpha}U_2 > 4\underline{\alpha}+36\underline{\alpha}U_2+6(\overline{\alpha}-\underline{\alpha})(1+2\overline{\alpha}+2\underline{\alpha})\Delta \quad (2.43)$$

Combining (2.42) and (2.43)

$$(\overline{\alpha}-\underline{\alpha})(2U_2-\Delta) > 0 \Leftrightarrow$$
$$U_2 > \frac{\Delta}{2} \quad (2.44)$$
$$or$$
$$U_2 > -U_1$$

- Perfect labels

Efficient firm	**r∈[,]**	**p_1^{PL}**	**p_2^{PL}**	**D_1^{PL}**	**D_2^{PL}**
1	r∈[0,1]	$c_2 - \Delta$	c_2	1	0
2	r∈[1,+∞]	c_1	Δ	0	1

<u>Retailers' and manufacturer's profits</u>

Efficient firm	π_1^{PL}	π_2^{PL}	π_m^{PL}
1	$c_2 - c_1 - \Delta$	0	c_1
2	0	$\Delta - (c_2 - c_1)$	c_2

- Comparison

➢ <u>Efficient firm</u> : 1

Firm 1	$\pi_1 > \pi_1^{PL}$
	$\pi_1^{d1} > \pi_1^{PL}$
Firm 2	$\pi_2 > \pi_2^{d1} = \pi_2^{PL}$
Upstream monopolist	$\pi_m^{d1} = \pi_m^{PL}$

➢ <u>Efficient firm</u> : 2

Firm 1	$\pi_1 > \pi_1^{d2} = \pi_1^{PL}$
Firm 2	$\pi_2 > \pi_2^{PL}$
	$\pi_2^{d2} < \pi_2^{PL}$
Upstream monopolist	$\pi_m^{d1} = \pi_m^{PL}$

Moreover it is worthwhile including the comparison in manufacturer's profits between the perfect label and the case of absence of label with dominant firm

$$\pi_m^{PL} = c_i$$
$$\pi_m^{di} = c_i \qquad (i = 1, 2)$$
$$\pi_m = \sum_i^2 c_i D_i$$

		Perfect label	
		Efficient firm 1	Efficient firm 2
No label	Dominant firm 1	$\pi_m^{PL} = \pi_m^{d1}$	$\pi_m^{PL} > \pi_m^{d1}$
	Dominant firm 2	$\pi_m^{PL} < \pi_m^{d2}$	$\pi_m^{PL} = \pi_m^{d2}$
	Duopoly	ambiguous	ambiguous

The comparison between duopoly and another case cannot reveal which one is more profitable since it all depends on

$$\pi_m^{d1} < \pi_m \Leftrightarrow$$
$$c_1 < (\bar{a}-\underline{a})^2 c_1 \Delta^2 + \frac{\left(1+2\bar{\alpha}-4\underline{\alpha}\right)^2 \Delta\left(-1+6\Delta(\bar{a}-\underline{a})\right)}{216(\bar{a}-\underline{a})}$$
$$or \tag{2.45}$$
$$\pi_m^{PL} > \pi_m \Leftrightarrow$$
$$c_1 > (\bar{a}-\underline{a})^2 c_1 \Delta^2 + \frac{\left(1+2\bar{\alpha}-4\underline{\alpha}\right)^2 \Delta\left(-1+6\Delta(\bar{a}-\underline{a})\right)}{216(\bar{a}-\underline{a})}$$

Simplifying (2.45)

$$\pi_m^{d1} < \pi_m \qquad iff$$
$$((\bar{a}-\underline{a})^2 \Delta^2 - 1) > 0 \quad and \quad \bar{a} > \frac{1}{6\Delta} + \underline{a} \tag{2.46}$$

The same follows for firm 2

$$\pi_m^{d2} > \pi_m \Leftrightarrow$$
$$\frac{1}{(\bar{a}-\underline{a})^3 \Delta}\left(1+2\bar{\alpha}-4\underline{\alpha}\right)\left(1+2\bar{\alpha}-4\underline{\alpha}+6\left(1+4\bar{\alpha}-2\underline{\alpha}\right)\left(\bar{a}-\underline{a}\right)\Delta\right) < 0$$
$$or$$
$$\pi_m^{PL} > \pi_m \Leftrightarrow$$
$$\frac{1}{(\bar{a}-\underline{a})^3 \Delta}\left(1+2\bar{\alpha}-4\underline{\alpha}\right)\left(1+2\bar{\alpha}-4\underline{\alpha}+6\left(1+4\bar{\alpha}-2\underline{\alpha}\right)\left(\bar{a}-\underline{a}\right)\Delta\right) < 0 \tag{2.47}$$

Simplifying (2.47)

$$\bar{\alpha} > 2\underline{\alpha} - \frac{1}{2}$$
$$and$$
$$\left(1+2\bar{\alpha}-4\underline{\alpha}+6\left(1+4\bar{\alpha}-2\underline{\alpha}\right)\left(\bar{a}-\underline{a}\right)\Delta\right) > 0 \Leftrightarrow \tag{2.48}$$
$$\bar{\alpha} > \frac{\underline{\alpha}}{2} - \frac{1}{4}$$

Last but not least it seems quite interesting whether the changes in retailers' profits are orientated in the same direction as the one of upstream monopolist

		Perfect label	
		Efficient firm 1	Efficient firm 2
No label	Dominant firm 1	$\pi_1^{d1} > \pi_1^{PL}$	=0
	Dominant firm 2	=0	$\pi_2^{d2} < \pi_2^{PL}$
	Duopoly	$\pi_1 > \pi_1^{PL}$	$\pi_2^{PL} <> \pi_2$

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