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Modeling the impact of private quality standards on the fresh fruit and vegetable supply chains in developing countries

Damien Fontaine, Frederic Gaspart, and Bruno Henry de Frahan

Paper prepared for presentation at the 12th EAAE Congress
'People, Food and Environments: Global Trends and European Strategies',
Gent (Belgium), 26-29 August 2008

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Modelling the impact of private quality standards on the fresh fruit and vegetable supply chains in developing countries

Damien Fontaine, Frédéric Gaspart and Bruno Henry de Frahan
Université catholique de Louvain, Louvain-La-Neuve, Belgium.

Abstract

Stricter quality requirements and greater uses of private quality standards have a considerable impact on the fresh fruit and vegetable supply chain in developing countries. In particular, the future of small-scale production is in doubt. This paper presents a theoretical game theory model to study the impact of quality requirements on producer and consumer welfare within certified supply chains. The model shows that total producer welfare is maximized at higher quality levels where farmers who are efficient in the production of quality products participate, whilst less efficient producers are excluded. In addition, the model provides useful insights on welfare and poverty impact of increased competition and changes in private standard certification costs.

Keywords : Fruit and vegetables, private quality standards, game theory.

1 Introduction

Over the last 15 years, the fresh fruit and vegetables (FFV) subsector has evolved dramatically in developing countries, leading to a thorough rationalization of supply chains and an increasing use of private quality standards, either business-to-business (e.g., GlobalGAP, SQF100) or business-to-consumer (e.g., Tesco's Nature's Choice, Carrefour's Filière Qualité). These changes have been driven by the retail sector that has considerably increased its market power in the context of multinationalization and globalization of the agri-food sector. The emergence of private standards has initially acted as a response to the regulatory development in the European Union (EU) that has tightened public standards and increased food safety liability for private actors following high profile food scares in the 1990s. In the European FFV subsector, the most important legal evolution has been the

review of the pesticide legislation (EC Regulations 396/2005) and the general food safety regulation (EC regulation 178/2002) imposing the traceability of food products within the EU (Codron *et al.*, 2005; Henson and Reardon, 2005). In some EU member countries, national legislation has become even more stringent than the community rules. The UK has, for instance, introduced the principle of *due diligence* that transfers food safety liability to the retailer unless it has taken all measures to avoid the eventual outbreak of any food safety issue (Bignebat and Codron, 2006).

In addition to compliance with legal requirements, private standards offer several benefits to retailers. These benefits include improved brand image, world-wide standardization of products and delivery attributes across suppliers, facilitation of year-round standardized supply, upstream transfer of production and commercial risks linked to legal liability and, in general, reduction in transaction costs (Henson and Reardon, 2005; Reardon *et al.*, 2005; Bignebat and Codron, 2006; Hatanaka *et al.*, 2005). In developing country markets, private standards may also substitute for missing public institutions or guarantee the enforcement of otherwise not-enforced public standards. These private standards play an important role in product differentiation as they allow supermarkets to introduce credence quality attributes related to environmental (e.g., organic products, food miles), social (e.g., labour conditions) or ethical (fair trade) production criterions. As a result, they enable the development of high-value agricultural and food markets. Supermarkets that used to compete on volume and cost can consequently also compete on consumer-valued quality attributes. New products or product attributes are continuously entering the market. In the FFV subsector, the healthy 'superfruits' are expected to be the latest novelty. In addition to the credence quality attributes, other value-adding tasks, such as washing, trimming, bar-coding and labeling are also increasingly being transferred to producers (Dolan and Humphrey, 2000; Humphrey *et al.*, 2004). It can therefore be argued that private standards have enabled the FFV market to shift away from increasingly commodified markets for unprocessed FFV to diversified high-value processed and semi-processed products that are subject to strict food safety and quality control (Jaffee and Masakure, 2005). Experts and supermarket category managers expect that quality requirements continue to rise along with this diversification and specialization process.

Fulponi (2006) reports that private standards are generally imposed by all supermarkets in industrialized countries. Given the large market share of supermarkets in FFV sales in most industrialized countries, private standards have therefore become *de facto* mandatory for the majority of their suppliers in developing countries (Martinez and Poole, 2004).[1] What is more, compliance to business-to-

[1] This is particularly true in the northern part of Europe, where retailer market shares in FFV can rise as high

business private standards such as GlobalGAP is also gradually being requested in lower quality markets such as wholesalers and food service industries.

The greater use of private quality standards is of particular relevance for developing countries where FFV is one of the most dynamic and promising export sectors (Swinnen and Vandeplas, 2007; Weinberger and Lumpkin, 2007). Between 1980-81 to 2000-01, the share of fresh and processed fruit and vegetable products has risen from 16.7 to 21.8 percent of total agricultural exports from developing countries (Diop and Jaffee, 2005). The FFV export from those countries is a considerable source of revenue for many small-scale growers (SSG). In African, Caribean and Pacific (ACP) countries, for example, it is estimated that the livelihood of approximately 3.5 million people depend on the FFV sector (COLEACP, 2007). This development is expected to continue along with the rise in quality standards, providing that additional developing country producers are able to comply with these standards.

Furthermore, quality standards are not only being requested for markets in industrialized countries. Following the rapid rise of supermarkets in developing countries, quality standards for high quality markets in developing countries are converging towards those in the retail export supply chains (Reardon *et al.*, 2005; Balsevich *et al.*, 2003; Berdegue *et al.*, 2005). Actually, quality standards for domestic use are likely to dominate export quality standards as the potential local outlet is much larger. In Latin America and China, sales of local products in domestic supermarkets are already more than twice larger than the exports of those products to the rest of the world (Reardon *et al.*, 2005). Over the next 25 years, more than half of the growth in global food retail markets is expected to come from markets in emerging economies (Brown, 2005).

In contrast to producers in industrialized countries who benefit from appropriate infrastructure, effective institutional systems and agricultural policies that facilitate a widespread adoption of good agricultural practices and environmental standards, producers in developing and emerging economies may encounter severe difficulties in complying to increasing levels of quality standards. These difficulties generally result from idiosyncratic market failures characterizing FFV production (Swinnen and Vandeplas, 2007) and the informational, financial and educational constraints of producers in these countries. The next section shows that these constraints have initially been mitigated through increased vertical integration, including the use of contractual arrangements. Nevertheless, because sourcing from SSG is expensive, exporters are gradually relying on larger suppliers.

Several papers have described the impact of private standards on the devel-

as 80 percent in the UK (Brown, 2005).

opment of supply chains in developing countries (Dolan and Humphrey, 2000; Graffham *et al.*, 2006; Minten *et al.*, 2007; Masakure and Henson, 2005; Chemnitz, 2007; Kleinwechter and Grethe, 2006; Reardon and Flores, 2006; Berdegue *et al.*, 2005). Most authors agree that stricter standard requirements tend to exclude SSG from the high quality supply chains. Few authors have, however, studied the welfare implications of these standards. Based on limited household surveys in Kenya, McCulloch and Ota (2002) find that horticultural SSG supplying export companies in Kenya benefit from higher incomes than non-horticultural SSG. Humphrey *et al.* (2004) elaborate this result and suggest that export horticulture has a poverty-reducing effect. They estimate that FFV exports in Kenya increase employment opportunities through the creation of jobs both in rural areas through hired labour on large farms or exporter estates and urban areas in packaging and processing industries. Maertens and Swinnen (2006) obtain a similar result in Senegal. Using company and household survey data from vegetable exports, they estimate that high-standard trade reduces regional poverty by about 12 percent and extreme poverty by half. Finally, Asfaw *et al.* (2007) show the positive income effect of participation in EurepGAP for SSG producers in Kenya. They also suggest that there is a potential local multiplier effect for employment and economic growth linked to the adoption of quality standards. Despite difficulties in proving causality, these empirical studies show an association between the adoption of private standards and an increase in income.

However, little theoretical work has been provided on the impact of high quality supply chains on welfare. Swinnen *et al.* (2008) develop a theoretical framework to study the introduction of high quality standards in developing countries. Considering a low quality and a high quality supply chain, their model shows that differences in initial conditions and characteristics of the economy affect the efficiency and equity outcomes of the development of a high quality supply chain. The authors conclude that most farmers in poor developing countries are likely to benefit where a high quality standard supply chain emerges. However, since this model only considers two levels of quality, it cannot examine relations between quality levels, strategic choices of economic actors and welfare. This paper proposes a model with a continuous range of quality levels to study their impact. In contrast to previous theoretical papers focusing on food safety quality (MacLaren, 2002; Bureau *et al.*, 2001), the model introduces quality certification and, hence, assumes symmetric information with regard to quality. Using industrial organization theory, the model analyses the quality-setting process for certified supply chains with different competition settings that can occur in developing countries. From this analysis, the impact on welfare and SSG participation is derived. Analytical results from the model show that producers that are less efficient in meeting quality are excluded as quality standards rise but that total producer welfare may still increase. These results confirm conclusions reached by the existing empirical

studies.

The next section of this paper describes the development of high quality supply chains in developing countries and highlights the current possible competition settings of supply chains. The third section presents the theoretical model for these competition settings and the fourth section gives the analytical results. Based on these results, the fifth section discusses in particular the relation between quality and welfare, the standard-setting process by public authorities and private supermarkets, the impact of the strength of competition within the supply chains and equity issues of the on-going development, including producer participation.

2 Development of high quality supply chains

In relation with the rising use of private quality standards, high quality export supply chains in developing countries have evolved considerably with a focus on increased efficiency. Even though the nature of different supply chains can vary across regions and countries depending on the local market conditions, six major features characterize the current high quality supply chains :

1. **Rationalisation in supply chain**
   The major characteristic is that the number of actors along the supply chain has been reduced in comparison to the early 1990s when spot market transactions and atomic merchants were the rule. Traditional intermediaries are now largely by-passed as the export supermarket supply chain is only constituted of producers, exporters, importers and supermarkets. This rationalisation is still on-going and is likely to deepen further. Some exporters are, for example, increasingly taking over the production role from SSGs and sourcing from estate land (Reardon *et al.*, 2005).

2. **Increase in quality**
   The increase in quality requirements goes along with the development of the supply chain. Until the mid-1990s, quality was confined to a limited concern for cosmetic and flavour characteristics (Reardon *et al.*, 2005). Control for credence characteristics such as food safety or environmental and social attributes could only be tightened in more rationalized and vertically integrated supply chains. FFV can then be sourced from selected growers who have the necessary education, training and infrastructure to meet the specific quality expectations of supermarkets.

3. **Development of interfirm linkages**
   Companies along the supply chain have built privileged relationships among themselves (Dolan and Humphrey, 2000; Reardon and Flores, 2006). The

category manager of an importing supermarket works with a limited number of importers and each importer has an exclusive business relation with one exporter in every country for each product. In turn, exporters source from a limited number of privileged producers that have the desired accreditation. Within the distribution intermediaries, supermarkets enjoy a considerable market power that results from the relatively high level of downstream market concentration. As such, supermarkets become the dominant actor in the supply chain by imposing their conditions to the other actors. In this context, the supply chain can be seen as being constituted of three main actors: producers, consumers and a group of intermediaries comprising exporters, importers and supermarkets in which decisions are made by supermarkets.

4. **Vertical integration at the producer level**
   Upstream, this vertical integration is increasingly taking the form of contracts that enable longer term relationships between producers and exporters. The use of contract farming constitutes a major change for producers that were used to spot market transactions. Increasing vertical integration facilitates the transfer of the desired processing and efficient management techniques that are required for standard compliance and reduces transaction and monitoring costs (Young and Hobbs, 2002). In addition, vertical integration is necessary to circumvent the imperfections in credit, input and output markets characterizing SSG production in developing and emerging economies. These longer term relations facilitate a proactive attitude of exporters or supermarkets in mitigating these idiosyncratic market failures, resulting in increased market efficiency (Swinnen and Vandeplas, 2007). However, as shown by case studies in Kenya reporting the share of establishment and maintenance cost covered by the exporter as well as the level of technical assistance, training and inputs offered to producers (Graffham *et al.*, 2006), the level of upstream vertical integration varies widely across supply chains.

5. **Third-party certification for private standards**
   In the 1990s, when private standards first made their breakthrough in export horticulture, second-party certification was the common rule. Supermarkets generally supervised producer compliance. However, private standards now widely use third-party certification to control producer compliance. Producers take charge of certification costs, which largely reduces the transaction costs for supermarkets (Hatanaka *et al.*, 2005).

6. **Upstream distribution of activities**
   Just as is the case for the transfer of supervision to third-party certification agencies, supermarkets are increasingly transferring supply chain activities and responsibilities upstream. Supermarkets now mainly focus on branding, product innovation, product design and marketing and have transferred the other tasks such as logistics, storage, distribution, transport and training of

producers to importers and exporters. Producers are also increasingly given additional production tasks, such as washing, pre-cutting and even packaging and labelling FFV (Dolan and Humphrey, 2000). This transfer is an important evolution since such processing activities require important infrastructural and managerial resources and generally generate important economies of size.

Overall, current high quality FFV supply chains include third-party certified producers, consumers and a block of distribution intermediaries constituted of one exporter, one importer and one dominant retailer. However, within this general frame of supply chain, actual supply chains can still show important variations following differences in producer organization as well as upstream and downstream market concentration. Upstream, the bilateral bargaining power between producers and exporters depends upon the competition level between exporters and the degree of vertical integration (Swinnen and Vandeplas, 2007). Downstream, market power enjoyed by supermarkets depends upon the degree of product differentiation provided by the standard. In developing countries, actual market conditions of FFV supply chains could theoretically range from perfect competition (when products are relatively undifferentiated and intermediaries do not use much of market power) to perfect monopoly (when products are sufficiently differentiated to create a market niche at the retail level) and/or monopsony (when the intermediary benefits from a monopolistic position at the farm gate). This paper therefore models the certified supply chain under the different market conditions that can occur in the actual developing country markets.

In response to the on-going supply chain development, producers are looking for institutional innovations. Standard specifications generally allow for group certifications where the producers share a part of the certification cost. SSG producers who cannot afford individual certification therefore organise in groups or cooperatives, usually with the support of an exporter, to reduce individual certification costs. In the following section, we propose a model to study the current high quality supply chains in developing countries as described in this section; allowing for the different competition settings and for groups of producers sharing certification costs.

3 The theoretical model

Consider a market for a product that has a continuous range of possible quality levels. Quality is unidimensional and is observed by all actors due to certification. Producer and consumer participation in the market of certified quality is free. Producers face a binary choice of whether or not to participate and supply one unit of

certified product. Producers who do not participate can supply the non-certified market. Consumers face a binary choice of whether or not to demand one unit of certified product. Only one level of certified quality is traded between producers and consumers.

Based on Tirole (1989), a consumer utility function that is monotone and linear in quality level is considered.

$$U_j = \theta.j - P_c \qquad\qquad j \in [0;1] \tag{1}$$

where there is an infinity of consumers whose type j, ranging from 0 to 1, reflects the value each consumer attaches to a quality level θ. The quality parameter θ can reflect the level of different types of quality in the FFV subsector: food safety (e.g., pesticide residues, microbiological contaminants), social or environmental processing standards, degree of processing, *etc.* Consumers of type $j \to 0$ do not value quality, whilst consumers of type $j \to 1$ value quality considerably. P_c is the price paid by the consumer for the product of certified quality level θ.

Given that consumers only participate for $U_j \geq 0$, consumers participate if

$$j \geq \underline{j} = \frac{P_c}{\theta}$$

where $\underline{j}$ is the type of consumer whose utility is zero and is indifferent whether to demand the certified product.

The producer utility is the following:

$$U_i = P_p - \theta^{a+1}(1-i) - F \qquad\qquad i \in [0;1] \text{ and } a > 1 \tag{2}$$

where there is an infinity of producers whose type i, ranging from 0 to 1, reflects the capacity of each producer to supply quality level θ. For a producer of type $i \to 1$, it is not costly to supply quality level θ. The more the producer type i tends to 0, the more it is costly for him to supply at quality level θ. Parameter i synthesizes all factors that determine the capacity to comply with quality requirements as described above, such as farm size, education, asset holding, etc. P_p is the price premium received by the producer compared to the product in the non-certified quality supply chain. F is the individual cost of certification. The costliness of producing quality depends upon parameter a. The utility of an individual producer decreases with the level of quality requested : $\frac{\partial U}{\partial \theta} < 0$. The marginal cost of producing quality is higher at greater quality levels : $\frac{\partial^2 U}{\partial \theta} < 0$.

Producers participate in the certified-quality supply chain if their utility is greater than their utility in the non-certified quality supply chain. If the producer

utility in the non-certified quality supply chain is zero, then producers participate for:

$$i \geq \underline{i} = 1 - \frac{P_p - F}{\theta^{a+1}}$$

where $\underline{i}$ represents the type of producer whose utility is zero and is indifferent whether or not to supply the certified product.

When producers are organized in groups to share the cost of certification, the utility of these producers changes into the following :

$$U_i = P_p - \theta^{a+1}(1 - i) - \frac{C}{(1 - \underline{i})} \qquad i \in [0; 1] \text{ and } a > 1 \tag{3}$$

where $(1 - \underline{i})$ represents the size of the group within which the certification cost is shared and C the certification cost for the group of producers. This common certification cost C cannot be compared to the certification cost of the individual producer F as they are of different orders. Since there is an infinity of individual producers within the interval of participating producers $[(1 - \underline{i}) ; 1]$, the certification cost C is shared within an infinity of producers of the same group. As such, the individual certification cost is infinitely high for an individual producer of the group, whilst the individual certification cost F is finite for an individual producer outside of the group.

The supply and demand functions are derived as follows.

From equation (1), the quantity demanded and the inverse demand function for a given quality requirement θ are respectively:

$$q = 1 - \frac{P_c}{\theta} \tag{4}$$

$$P_c = \theta(1 - q) \tag{5}$$

From equation (2), the quantity supplied by the individual producers and the inverse supply function for a given quality requirement θ are respectively:

$$q = \frac{P_p - F}{\theta^{a+1}} \tag{6}$$

$$P_p = q\,\theta^{a+1} + F \tag{7}$$

When producers are organised in groups to share the certification cost, the individual utility of each producer determines its participation choice. Again, only producers for which $U_i \geq 0$ participate in the certified market. If $\underline{i}$ is the producer

for which $U_i = 0$, the size of the group is $(1 - \underline{i})$. From equation (3), solving for $(1 - \underline{i})$, we find two equilibria for the size of the producer group and the quantity produced: a large group of relatively less efficient producers and a smaller group of more efficient producers.

$$\text{Size of the large group :} \qquad 1 - \underline{i} = q = \frac{P_p}{2\,\theta^{a+1}} - \frac{\sqrt{P_p^2 - 4\,C\,\theta^{a+1}}}{2\,\theta^{a+1}} \tag{8}$$

$$\text{Size of the small group :} \qquad 1 - \underline{i} = q = \frac{P_p}{2\,\theta^{a+1}} + \frac{\sqrt{P_p^2 - 4\,C\,\theta^{a+1}}}{2\,\theta^{a+1}} \tag{9}$$

From equations (8) and (9), the inverse supply function of the group is derived as follows :

$$P_p = q\,\theta^{a+1} + \frac{C}{q} \tag{10}$$

At equilibrium, the individual certification cost is lower for members of the large group than for members of the small group since the certification cost is shared by a larger number of producers. This enables less efficient producers to participate in the supply chain of certified quality. Because members of the small group are on average more efficient in meeting the quality requirements, they can afford a higher individual certification cost.

These two types of groups react differently to changes in the parameters of the model. For the large group we find as expected that $\frac{\partial(1-\underline{i})}{\partial\theta} < 0$, $\frac{\partial(1-\underline{i})}{\partial P} > 0$ and $\frac{\partial(1-\underline{i})}{\partial C} < 0$. However, for the small group we find the opposite effect : $\frac{\partial(1-\underline{i})}{\partial\theta} > 0$, $\frac{\partial(1-\underline{i})}{\partial P} < 0$ and $\frac{\partial(1-\underline{i})}{\partial C} > 0$. For the small group, an increase in the certified quality level or the certification cost increases participation in the group whilst an increase in the price offered to producers decreases participation. We do not focus on these counter-intuitive effects since the properties of the equilibrium of the small group suggest that it is unstable. Figure 1 drawn from equation (3) shows that any change in production conditions leading to a decrease in the size of the small group (*i.e.*, an increase in producer price or a decrease in certification costs or quality level) decreases the utility of the least efficient member of the group. The departure of this member would in turn reduce the utility of the next least efficient member who would also leave the group. Eventually, the group collapses as

illustrated by the arrows around the unstable equilibrium. In contrast, any change leading to an increase in the size of the small group (*i.e.*, a decrease in producer price or an increase in certification costs or quality level) increases the utility of the least efficient member. This would attract less efficient producers into the group until the equilibrium of a larger group is reached. In contrast, as illustrated by the arrows around the equilibrium of the large group, this second equilibrium is stable.

Figure 2 illustrates the supply function drawn from equation (10). In this figure, the supply function of the small group is represented by the decreasing part of the curve and the supply function of the large group by the increasing part of the curve. Given the unstable nature of the small group equilibrium, we continue our analysis of the large group considering only the increasing part of the supply function.

On the basis of these supply and demand assumptions, we model the situation under perfect competition where quality is considered as exogenous and fixed by an external actor. We subsequently study the equilibrium solutions when a monopolistic and/or monopsonistic intermediary maximizes its profit with respect to quantity and quality. Quality is then endogenous.

4 Analytical results

4.1 Equilibrium for exogenous quality

In perfect competition with individual producers, we derive the equilibrium price and quantity from equations (5) and (7):

$$q^* = \frac{\theta - F}{\theta(1+\theta^a)} \tag{11}$$

$$P^* = \frac{\theta^{a+1} + F}{1+\theta^a} \tag{12}$$

This equilibrium is illustrated in Figure 3. We also derive the producer surplus, the consumer surplus and total surplus.

$$\text{Producer surplus :} \quad \frac{(P^* - F)q^*}{2} = \frac{\theta^a(\theta - F)^2}{2\theta(1+\theta^a)^2} \tag{13}$$

$$\text{Consumer surplus :} \quad \frac{(\theta - P^*)q^*}{2} = \frac{(\theta - F)^2}{2\theta(1+\theta^a)^2} \tag{14}$$

$$\text{Total surplus :} \quad \frac{(\theta - F)q^*}{2} = \frac{(\theta - F)^2}{2\theta(1+\theta^a)} \tag{15}$$

The equilibrium solutions allow us to study the impact of quality on the producer and consumer surplus. Figure 4 shows that the surplus of both producers and consumers initially increase with an increase in quality and then decrease beyond a certain quality level. For producers, the initial welfare increase reflects that, at low quality levels, producers would prefer a higher level of quality that increases producer price. However, as quality increases, production becomes more expensive and fewer producers are able to comply. The utility of efficient producers increases with quality, but total producer surplus decreases as a result of a decrease in producer participation. As consumers value quality, a higher level of quality initially increases their surplus. However, beyond a certain quality level, supply is reduced, price increases and consumer surplus decreases. Finally, the model shows that the producer participation rate in the certified quality supply chain and the traded quantity also increase initially before decreasing as quality requirements rise (see Figure 4).

Figure 4 shows that the quality level that maximizes producer participation and traded quantity is lower than the quality level that maximizes the surplus of both consumers and producers. Interestingly, producer surplus is maximized at a higher quality level than consumer surplus. At such high quality levels, prices are high and only very few efficient producers participate.

When producers share the certification cost, the equilibrium solutions in perfect competition with exogenous quality show the same characteristics as for the case with individual producers (Figure 5). The derivation of the equilibrium solutions is given in the Appendix.

4.2 Equilibrium for endogenous quality

In imperfect competition with endogenous quality, an intermediary, typically a supermarket, can set the traded quantity and quality levels such as to maximize its profit. From equation (7), the profit of a monopsonistic intermediary is the following :

$$\Pi = P_c q - P_p q = P_c q - \theta^{a+1} q^2 - F q \tag{16}$$

Profit maximization with respect to θ and q gives the equilibrium quantity and prices :

$$q^* = \frac{\theta - F}{\theta + 2\theta^{a+1}} \tag{17}$$

$$P_p^* = q^* \theta^{a+1} + F = \frac{\theta^{a+1} + F\theta^a + F}{1 + 2\theta^a} \tag{18}$$

$$P_c^* = \theta(1 - q^*) = \frac{2\theta^{a+1} + F}{1 + 2\theta^a} \tag{19}$$

Figure 6 illustrates this equilibrium. We derive the producer surplus, the consumer surplus, the intermediary surplus and total surplus :

$$\text{Producer surplus :} \quad \frac{(P_p - F)q}{2} = \frac{\theta^a(\theta^2 - F^2)}{2\theta(1 + 2\theta^a)^2} \tag{20}$$

$$\text{Consumer surplus :} \quad \frac{(\theta - P_c)q}{2} = \frac{(\theta - F)^2}{2\theta(1 + 2\theta^a)^2} \tag{21}$$

$$\text{Intermediary surplus:} \quad (P_c - P_p)q = \frac{\theta^a(\theta - F)^2}{\theta(1 + 2\theta^a)} \tag{22}$$

$$\text{Total surplus} = \text{Producer surplus} + \text{Consumer surplus} + \text{Intermediary surplus} \tag{23}$$

The equilibrium solutions under monopoly and double monopoly are given in the Appendix. Figures 7 to 9 illustrate the surplus of the different actors as a function of quality for each of the imperfect competition settings. The results for producer participation and producer and consumer surplus are similar to those obtained in perfect competition with individual producers. Traded quantity and producer participation, both represented by parameter q, is reduced compared to the case of perfect competition. In the case of a double monopoly, the comparison of equations (11) and (29) gives a traded quantity and producer participation that are halved. Trade and participation are slightly higher both with a monopsony (equation 33) and a monopoly (equation 17), even though they are still below the traded quantity in perfect competition. However, there are relatively important changes in the optimal level of quality for the intermediary depending upon the nature of its market power. A monopsonistic intermediary sets its optimal quality level such as to maximize producer surplus and internalize it (Figure 7). In contrast, a monopolistic intermediary sets its optimal quality level such as to maximize consumer surplus and internalize it (Figure 8). Subsequently, the equilibrium quality level is higher with a monopsonistic intermediary than with a monopolistic intermediary. Finally, an intermediary acting as a double monopolist maximizes its profit at a quality level between the optimal quality level for consumers and the optimal quality level for producers. The optimal quality level for the intermediary in double monopoly is in fact the quality level that maximizes equation (15) representing total surplus in perfect competition.

4.3 Comparison of supply chains

Table 1 compares the equilibrium solutions and surpluses under the different competition settings of supply chains with isolated producers for one specific set of parameters.[2] As expected, surplus of both producers and consumers is higher in perfect competition than with an intermediary that limits trade. However, it is interesting to note that, at equilibrium, producer surplus is higher with a monopsonist than with a monopolist. Actually, with a monopolist, producer surplus is relatively high at high quality levels. However, at the lower quality level that maximizes the surplus of the monopolist, producer surplus is lower than with a monopsonist competition where the equilibrium quality level is the optimal quality level for producers (Figures 7 and 8). A similar analysis explains why the surplus of consumers is higher with a monopolistic intermediary than with a monopsonist. The surplus of both producers and consumers is lowest under double monopoly. The intermediary maximizes its profit when it can act as a double monopolist.

Participation of producers and traded quantity, estimated by q, is by far the greatest under perfect competition but the lowest under double monopoly. However, as expected, producer participation is greater with a monopolist than with a monopsonist.

4.4 Changes in certification costs

The study of the impact of a change in the cost of certification is of particular interest for the high-quality FFV subsector in developing countries. Services of certification agencies are relatively scarce and expensive in those countries. As certification becomes more widespread, costs are likely to decrease in the future. Nevertheless, some producers may have to face an increase in certification costs in the future. This might particularly be the case for the SSG whose costs of quality compliance are currently supported by development agencies and/or exporters. In this context, it is interesting to understand the impact of a change in certification cost on welfare.

The analytical model shows that a change in certification costs simultaneously alters the equilibrium level of quality, the surplus of the actors and the traded quantity. Since the impact of a change in certification costs on the surplus varies according to the quality level of the traded product, we study the impact of certification cost changes at different theoretical quality levels: the social optimum in perfect competition (θ_s^*), the optimal level for consumers (θ_c^*), the optimal level for producers (θ_p^*) and the optimal level for the intermediary in the different imperfect competition settings (θ_m^*). We derive numerically the direction of the changes

[2] Given the difference in nature of the certification cost parameter, the case with individual producers could not be compared with the case of producers sharing the certification cost (see above).

in the optimal levels of quality, traded quantity or, equivalently, producer participation and participant surplus with respect to the certification costs F and C. The sign of these comparative statics indicates the impact of a marginal change in certification cost on the equilibrium quality level, the traded quantity (or participation) and welfare.

Tables 2 and 3 give the comparative statics. In general, an increase in certification cost induces an increase in the optimal level of quality that is chosen by the participants both under perfect and imperfect competition. When producers share the certification costs, an increase in certification cost may, however, induce a decrease in their optimal quality level, which diminishes the optimal quality for the society as a whole (Table 2). An increase in certification costs always reduces traded quantity and producer participation (Table 3). An increase in certification costs generally reduces the surplus of the participants (Table 3). However, under some circumstances, an increase in costs may theoretically raise welfare for some actors. The model suggests that this can occur in perfect competition with producers not sharing certification costs and in imperfect competition with an intermediary acting as a double monopolist (Table 3). In such a case, the positive effect on producer surplus of an increase in quality resulting from an increase in certification costs overcompensates the reduction in production or consumption resulting from the cost increase.

5 Discussion

5.1 Quality and welfare

The model clearly highlights the link between the level of quality and welfare within the different competition settings. It shows that, in each setting, producer welfare increases as quality requirements rise and reaches a maximum at a higher quality level than the one that maximises consumer welfare. As such, the model shows that the stricter quality standards could in theory contribute to alleviate poverty in developing countries. These analytical results fit well with field observations in Kenya. The highly efficient Kenyan producers have been keen to move to new high care products such as specialty vegetables with increased preparation level such as pre-cutting, packaging and labelling. This move has enabled them to increase both value and volume of their exports. This analytical result also supports the findings of the empirical studies of McCulloch and Ota (2002), Humphrey *et al.* (2004) and Maertens and Swinnen (2006) that report a positive effect of private standards on the income of the participating producers and on poverty reduction.

5.2 Choice of quality level

The analytical results provide some insight on the public standard-setting process. Akerlof's market for lemons (Akerlof, 1970) shows that the presence of asymmetric information on product attributes can lead to the disappearance of the market. An intervention of a benevolent actor, typically the public authority to set a minimum quality level to be reached by producers would therefore be necessary in the absence of private standards for credence characteristics in horticultural products. In the best of the worlds, a government would set the quality level such as to maximize total welfare inbedded in equation (15). However, political economy arguments may push a government to divert from this optimal quality level for several reasons. In developed countries, these include the fear of a food crisis (Gaisford and Kerr, 2001; Knowles *et al.*, 2007) and support of the agrifood sector in countries where producers are efficient in meeting high quality standards. Actual standards may then be stricter than the optimal standard. Otsuki *et al.* (2001) show with a gravity model that the strict EU high aflatoxin standards have a negative impact on cereals, nut and dried fruit trade from Africa. As a result, these standards can considerably affect inefficient producers and lead to increased prices for consumers.

Similarly to the situation with individual producers depicted above, the equilibrium solution with a group of producers sharing certification costs also suggests that efficient producers would maximize their global profit at high quality levels. The case of producers lobbying for geographical indication standards in the EU illustrates this phenomenon. These producers have a comparative advantage in the provision of a certain type of quality linked to a local geographical origin that is valued by consumers. They are therefore keen to promote strict standards to increase their total profit even though it increases their production cost. Often, they group to share the processing, infrastructure and promotion costs that are required for their specific production. To our knowledge, such producer demands for high quality have not yet been reported in developing countries, probably because of limited producer awareness of consumer preferences and market conditions, local legislative and institutional barriers for the development of new standards and difficulties for producers to organize themselves and voice their interest.

Companies in the private sector, in turn, have also an interest in setting high standards when they enjoy a monopsonistic position. In such setting, they maximise their profit by choosing the quality that maximizes the welfare of their suppliers, i.e. a higher quality level than the social optimum. In contrast, a monopolist maximizes its profit at a lower quality level than the social optimum. As a result, the public sector could intervene and impose a public standard that would maximize social welfare. In such setting, a supermarket that enjoys a monopolistic position may not develop a private standard scheme as producers have to meet

stricter public standard requirements. However, it is important to remark that other considerations may influence the choice of standards by supermarkets, such as legal food safety liability, reputation or competition. These considerations, that are not considered in the model, are nevertheless all arguments for supermarkets to increase private standard requirements resulting in an optimal quality level for the supermarket that may actually be higher than the one obtained in this model.

5.3 Strength of competition

As the comparative welfare analysis of the different supply chains shows, welfare of both producers and consumers is, in general, maximized under perfect competition. Increased competition, especially at the level of the retailers and primary producers, should therefore in theory be promoted to increase welfare. Swinnen and Vandeplas (2007) illustrate the ambiguous effect of competition in vertically integrated high-value supply chains. Their study suggests that an increase in competition could improve the bargaining power of the producers and, therefore, improve contract terms. However, in developing countries where markets are characterized by factor market imperfections, this could also result in less vertical integration as opportunistic behaviours such as side-selling may emerge under increased competition (Swinnen and Vandeplas, 2007; Delpierre, 2008). In such a case, downstream chain segments may stop assisting producers in the mitigation of idiosyncratic market failures and both producer and total welfare may actually decrease. Before promoting competition, it may therefore be necessary to remove first the existing market imperfections, through the improvement of input markets, credit facilities, training and transport. This is what has happened in several Mediterranean countries where the public sector is more involved in the provision of training and infrastructure. A greater bargaining power for the producers through the promotion of efficient producer organizations representing producers in front of their buyers is also helpful.

5.4 Participation of producers

The model shows that the quality level that maximizes producer participation is relatively low and below the optimal quality for consumers and producers across the different competition settings. As a result, the model suggests that any increase in quality, in the range of likely quality levels, leads to an exclusion of the least efficient producers participating in the supply chain (Figures 3 to 7). Existing field observations report that farm size contributes to the producer capacity to comply with quality standards. Mausch *et al.* (2006) compare the cost of compliance for EurepGAP of SSG, large farms and exporter-owned estates in Kenya and conclude that there are economies of scale linked to certified FFV production. Neven and Reardon (2006) and Asfaw *et al.* (2007) estimate on the basis of household surveys

in Kenya that adopters and non-adopters of EU private quality standards differ significantly in terms of farm size as well as other characteristics such as asset holding, irrigation, capital/labor ratio, education and access to services. With the assumption that parameter i in our model reflects in part the efficiency linked to the economies of size of certified production, the analytical results confirm the observed trend of displacement of SSG procurement by production on estates or large farms as quality requirements rise. If quality requirements continue to rise, through the transfer of processing or packaging activities upstream for instance, only the upper tier producers in terms of efficiency may manage to remain in the certified supply chain. Less efficient producers, mainly SSG, may not be able to comply with the additional requirements.

5.5 Impact on poverty

The impact on poverty of the exclusion of producers from high-quality FFV production following the increase in quality requirements is not clear-cut and depends upon the situation that prevailed locally before the development of certified supply chains. Where initially a low quality supply chain has prevailed, the introduction of an additional high quality outlet is likely to benefit producers. This has already been shown in Swinnen *et al.* (2008). Our model confirms this observation since efficient producers, with a high value for parameter i, participate in the certified quality supply chain and less efficient producers, with a low value for parameter i, continue to supply the non-certified market. In such a case, the economic surplus computed from our model can be interpreted as an additional surplus compared to the situation where only a low quality non-certified supply chain prevails. However, certified supply chains have generally replaced traditional non-certified export FFV production. Producers who cannot comply with the certified requirements may no longer be able to export and may need to move to lower value supply chains. Such producers would lose from the development of certified supply chains in terms of reduced revenues. This loss is reported in a survey of 102 farmers in Kenya showing a considerable decrease in income from farm production following exclusion from GlobalGAP (Graffham *et al.*, 2007).

Nevertheless, producers excluded from the certified supply chain may still participate in the certified supply chains as employees of large farms or exporter-owned farms. In such a case, they may still benefit from the development of certified supply chains. Neven and Reardon (2006), for instance, estimate that kale suppliers to Kenyan supermarkets hire workers for 80 percent of their labor needs and that wages to landless rural households are higher in the supermarket channel. Overall, the analytical results of the model suggest that the development of high quality standards leads to a rise in total producer income that is concentrated into the

hands of a reduced number of efficient producers. The actual impact on poverty depends upon the way welfare is redistributed. The benefits of increased quality could be redistributed to the excluded producers through an increased employment in the farming and processing stages.

5.6 Impact of certification costs

The comparative statics of the model suggest that, in general, a reduction in certification costs F or C induces an increase in producer participation and welfare for all the actors of the supply chain. Ways of reaching the same level of certified quality at lower costs in terms of audit, investment and other types of input should therefore be promoted. In particular, increased competition between certification agencies in developing countries where audits are generally expensive may result in lower certification costs.

The impact of a change in certification costs F or C could also be seen, more generally, as a change in fixed production costs. The comparative statics then suggest that any increase in fixed cost induces a rise in the optimal quality for producers. Field observations confirm this. Chan *et al.* (2000) for instance report that producers in Zimbabwe tend to switch to higher value horticultural products following the increase in pesticide residue standards in the EU.

6 Limitations of the model

As suggested above, actual market conditions and supply chain characteristics are much more complex than assumed in our model. The most important features of the FFV chain that are not accounted for in the model are the following.

1. **Economies of size**
   Most authors agree that there are economies of size linked to certified FFV production. This feature could be one of the main reasons for the progressive exclusion of SSG out of high-quality FFV production. However, our model sets the level of production for each producer at one unit. As suggested above, the efficiency parameter of each producer i could reflect the benefits of economies of size in compliance with quality production. However, it would be interesting to study the impact of size in a more specific way, as this is probably one of the main constraints faced by SSG.
2. **Unique level of quality**
   Our model assumes a single level of certified quality traded and provides

aggregate welfare levels for producers and consumers. However, in reality, there are generally several certified quality levels in the market. In developed countries, a main market with a minimum quality level, set either publiclè or privately by a widespread business-to-business standard such as GlobalGAP, generally coexists with a range of differentiated private high-quality standards that target consumers who value certain types of quality. Drawing from Mussa and Rosen (1978), we expect that introducing several quality levels in the model could alter the equilibrium solutions and welfare effects that we have obtained.

3. **Comparison with the non-certified supply chain**
   Field reports on the current high-quality supply chains show that price premiums associated with increases in quality requirements are inexistent or limited (Graffham *et al.*, 2006; Balsevich *et al.*, 2003). Some authors still warn that, given their bargaining power, supermarkets are able to transmit increasing quality requirements without necessarily matching with increased producer prices. However, producers may enjoy other types of benefits, such as the provision of inputs, credit, training and guaranteed outlets. The empirical studies mentioned above confirm this positive effect of participation in certified supply chain on income. Furthermore, positive externalities linked to the adoption of private standard codes of practice, such as improved farm management, increased yields and improved use of phytosanitary products are observed. The inclusion of such externalities in a model could help compare the welfare effect of non-certified and certified quality supply chains in more detail.

7 Conclusions

The model proposed in this paper provides a useful tool to highlight the impact of quality requirements on welfare of the different actors forming the certified quality supply chains. It focuses on the high-quality FFV export supply chains, even though it may also be used for the emerging high-quality FFV supply chains within developing countries or even other types of certified supply chains where quality plays an important role. The analytical results of the model seem to fit well with field observations in developing countries: a widespread exclusion of less efficient producers and an increase in welfare for participating producers following the increase in quality requirements. With the on-going focus on quality attributes in the agrifood sector, this trend is likely to continue. However, further work is required to improve our understanding of these supply chains. In particular, quality-based competition among supermarkets would require an additional attention since such

competition may lead to further increase in quality requirements and market segmentation.

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Figures

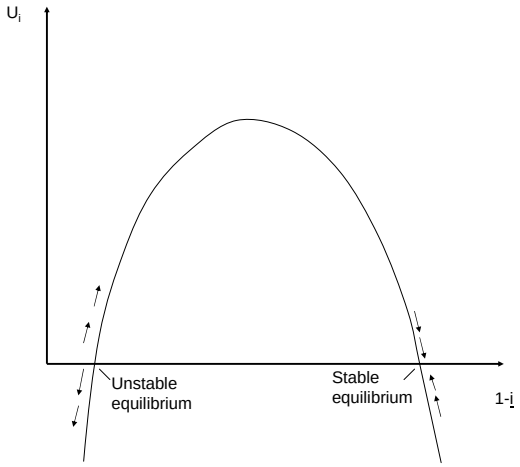

Figure 1: Equilibriums of the size of the producer groups

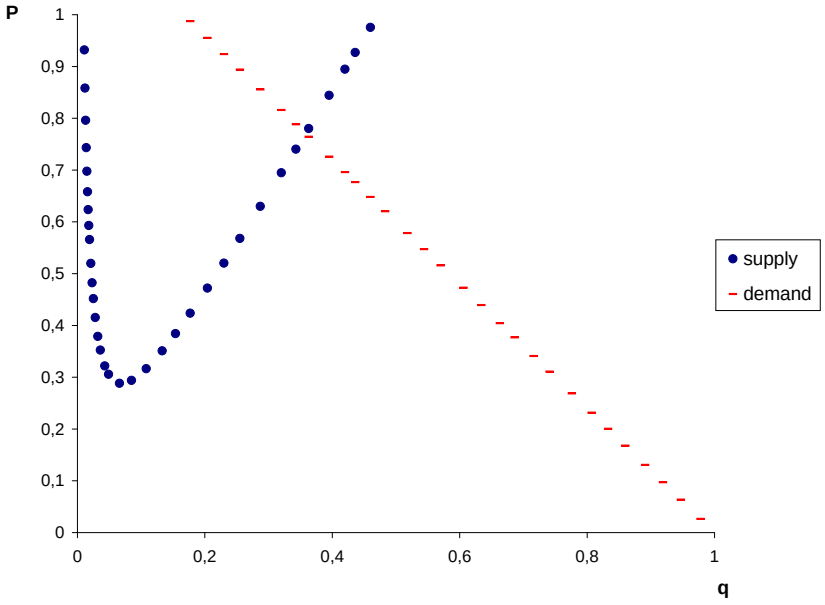

Figure 2: Supply and demand curves for the group of producers.

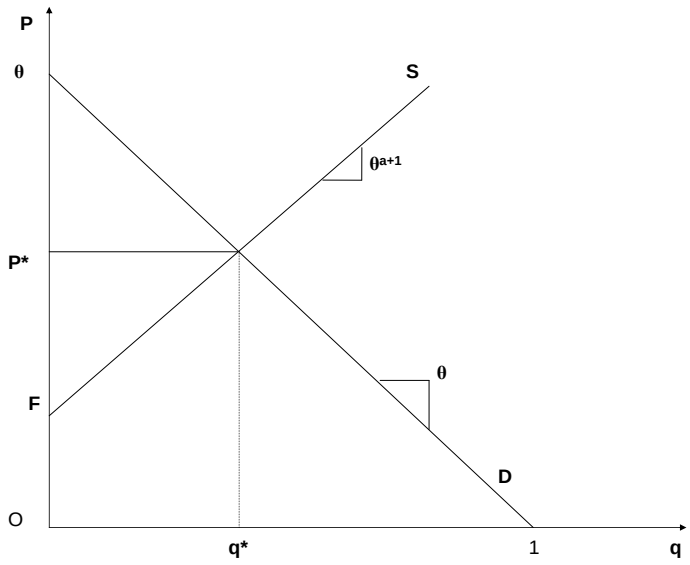

Figure 3: Supply and demand in perfect competition.

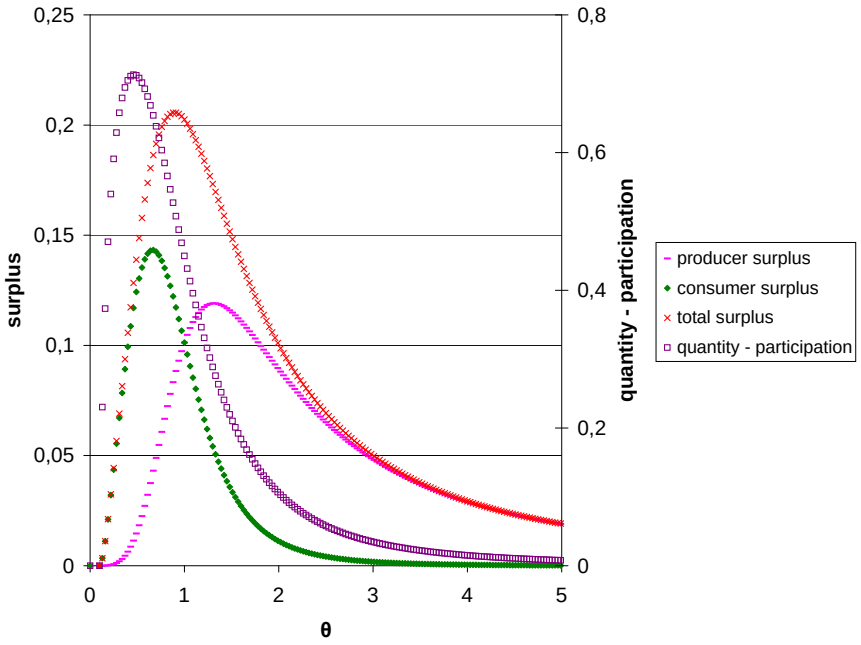

Figure 4: Impact of quality on welfare and certified market participation in perfect competition with individual producers.

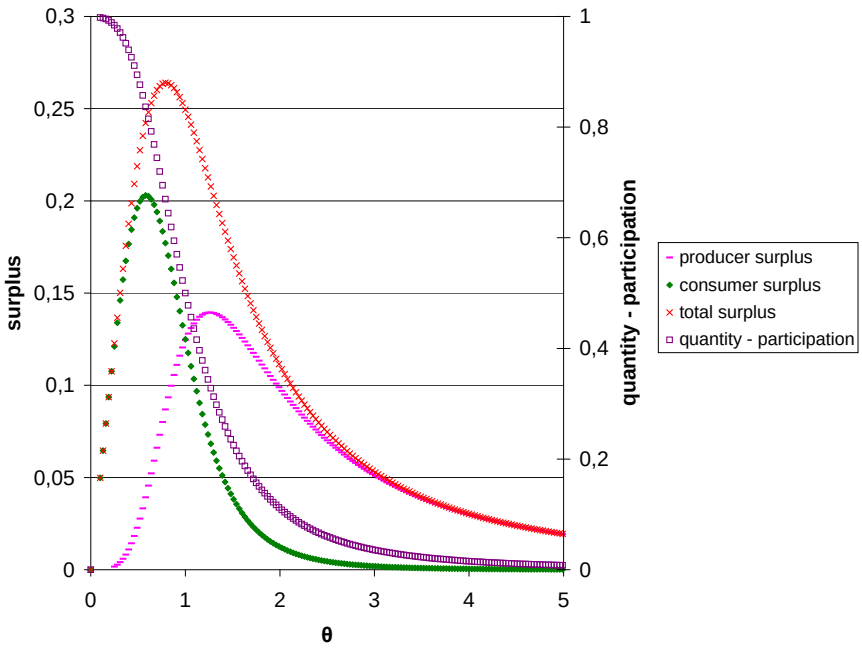

Figure 5: Impact of quality on welfare and certified market participation in perfect competition with a group of producers sharing certification costs.

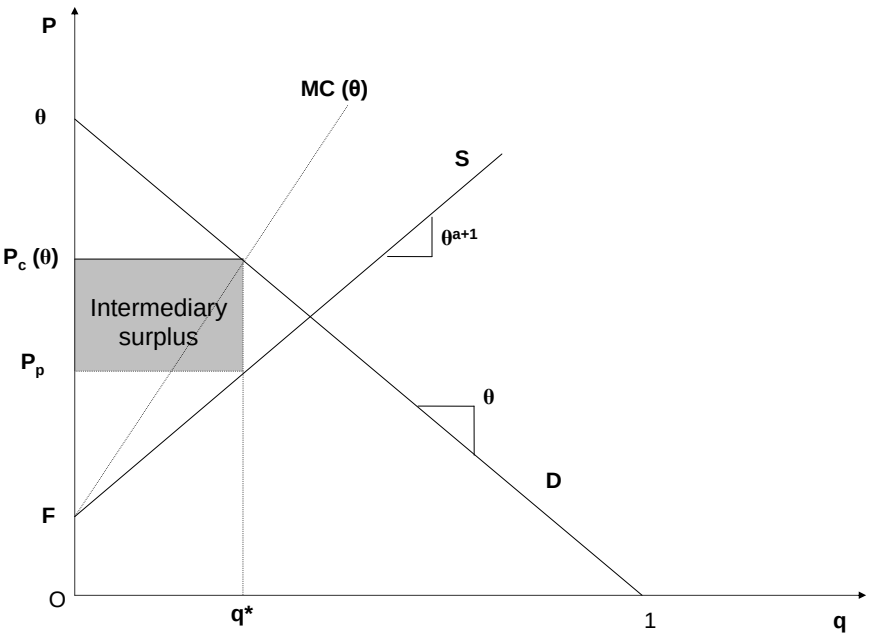

Figure 6: Supply and demand with a monopsonistic intermediary.

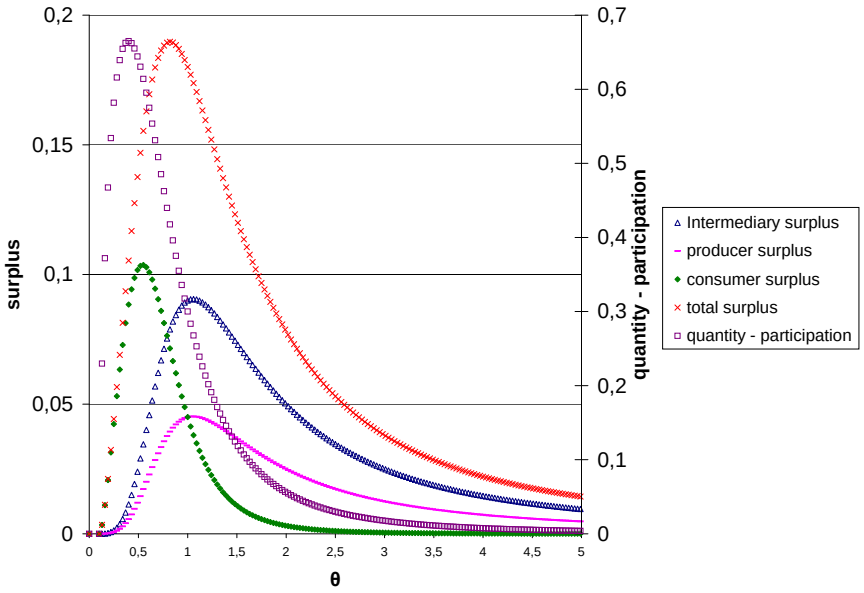

Figure 7: Impact of quality on welfare and certified market participation with a monopsonistic intermediary.

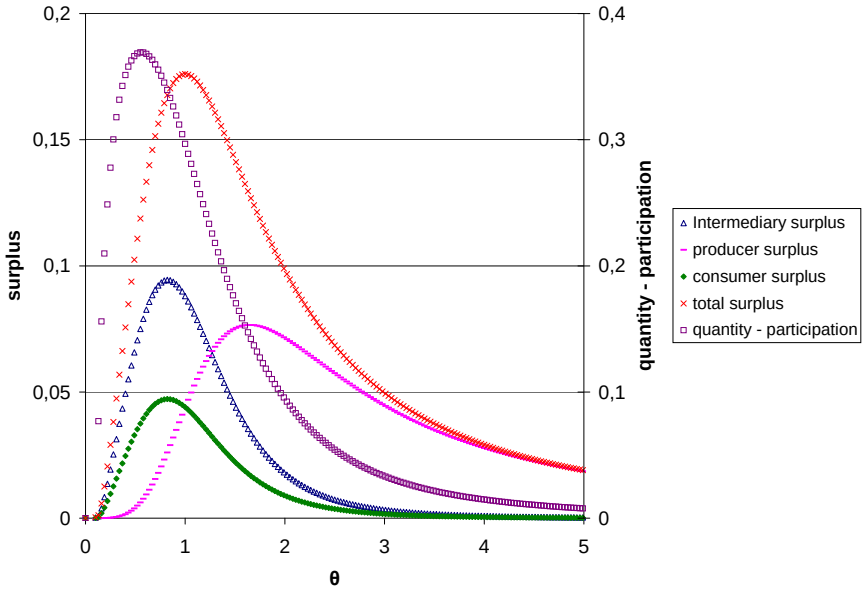

Figure 8: Impact of quality on welfare and certified market participation with a monopolistic intermediary.

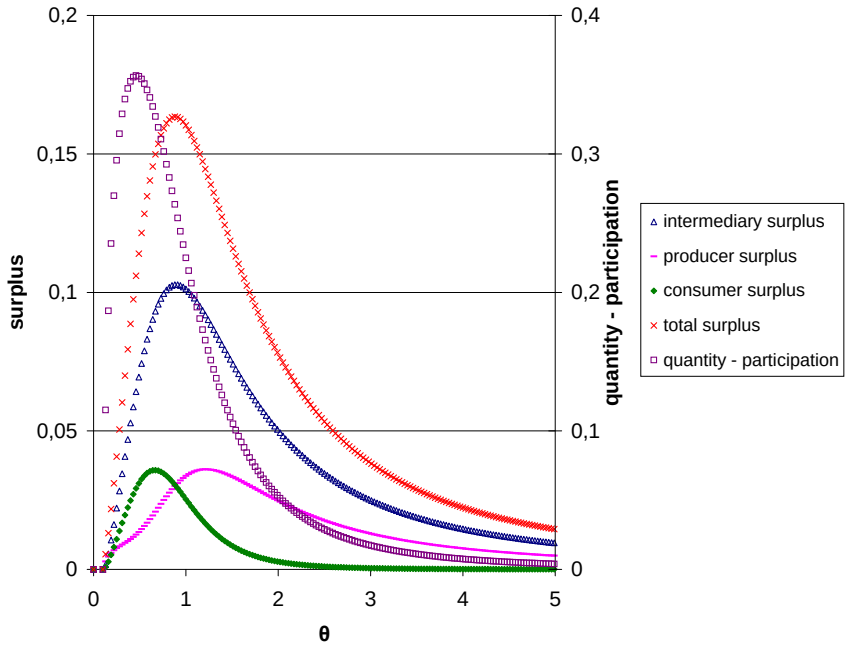

Figure 9: Impact of quality on welfare and certified market participation with a monopolistic and monopsonistic intermediary.

Tables

Table 1: Comparison of the equilibrium solutions for the different competition settings.[a]

Competition setting	Equilibrium quality level	Quantity - Participation	Consumer Surplus	Producer Surplus	Intermediary surplus	Total surplus
Perfect competition[b]						
- θ_s^*	0,89	0,521	0,121	0,085	-	0,206
- θ_p^*	1,31	0,284	0,053	0,119	-	0,172
- θ_c^*	0,66	0,659	0,143	0,041	-	0,185
Monopsony[c]	1,06	0,268	0,038	0,045	0,091	0,174
Monopoly[c]	0,82	0,339	0,047	0,026	0,094	0,168
Double monopoly[c]	0,89	0,260	0,030	0,030	0,103	0,163

[a] Results for the following model parameters : F = 0.1 and a = 3.
[b] θ_s^* = optimal quality level for the society; θ_p^* = optimal quality level for producers; θ_c^* = optimal quality level for consumers
[c] At optimal quality level for the intermediary

Table 2: Comparative statics of quality level with respect to certification cost for several competition settings

Competition setting	θ_s^*	θ_p^*	θ_c^*	θ_m^*
Perfect competition				
- Individual certification cost	+	+	+	N.A.
- Shared certification cost	-	+	-	N.A.
Monopsony	N.A.	N.A.	N.A.	+
Monopoly	N.A.	N.A.	N.A.	+
Double monopoly	N.A.	N.A.	N.A.	+

θ_s^* = optimal quality level for the society
θ_p^* = optimal quality level for producers
θ_c^* = optimal quality level for consumers
θ_m^* = optimal quality level for the intermediary

Table 3: Comparative statics of quantity or participation and surplus with respect to certification cost for several competition settings

Competition setting	Quantity - participation	Consumer surplus	Producer surplus	Total surplus	Intermediary surplus
Perfect competition: Individual certification cost					
- θ_s^*	-	-	-	-	N.A.
- θ_p^*	-	-	-	-	N.A.
- θ_c^*	-	-	+	-	N.A.
Perfect competition: Shared certification cost					
- θ_s^*	-	-	-	-	N.A.
- θ_p^*	+-	-	-	-	N.A.
- θ_c^*	-	-	-	-	N.A.
Monopsony	-	-	-	-	-
Monopoly	-	-	-	-	-
Double monopoly	-	-	+	-	-

θ_s^* = optimal quality level for the society
θ_p^* = optimal quality level for producers
θ_c^* = optimal quality level for consumers

Appendix : Equilibrium solutions for other competition settings

1. Perfect competition and certification cost sharing

From equations (5) and (10), we derive the equilibrium quantity and price :

$$q^* = \frac{\theta + \sqrt{\theta^2 - 4C(\theta + \theta^{a+1}}}{2\theta(1 + \theta^a} \tag{24}$$

$$P^* = \theta(1 - q) = \frac{\theta + 2\theta^{a+1} - \sqrt{\theta^2 - 4C(\theta + \theta^{a+1}}}{2(1 + \theta^a)} \tag{25}$$

We also derive producer and consumer surplus:

$$\text{Producer surplus} = \int_{2\sqrt{C\theta^{a+1}}}^{P^*} (\frac{P}{2\theta^{a+1}} + \frac{1}{2\theta^{a+1}}\sqrt{P^2 - 4C\theta^{a+1}})dP \tag{26}$$

$$\text{Consumer surplus} = \frac{(\theta - P^*)q^*}{2} \tag{27}$$

In perfect competition, total surplus is the sum of consumer surplus and producer surplus.

2. Imperfect competition and no certification cost sharing

In imperfect competition, the intermediary maximizes its profit through the choice of the quality level and the quantity exchanged.

1. Intermediary acting as a double monopolist.

   From equations (5) and (7), the profit of the intermediary is the following :

$$\Pi = \theta(1 - q)q - \theta^{a+1}q^2 - Fq \tag{28}$$

   Profit maximization with respect to θ and q gives the equilibrium quantity and prices :

$$q^* = \frac{\theta - F}{2\theta(1 + \theta^a)} \tag{29}$$

$$P_p = q^*\theta^{a+1} + F = \frac{\theta^{a+1} + \theta^a F + 2F}{2(1 + \theta^a)} \tag{30}$$

$$P_c = \theta(1 - q^*) = \frac{\theta + 2\theta^{a+1} + F}{2(1 + \theta^a)} \tag{31}$$

2. Intermediary acting as a monopolist.

   From equation (5), the profit of the intermediary is the following:

$$\Pi = \theta(1 - q)q - (P_p)q \tag{32}$$

   Profit maximization with respect to θ and q gives the equilibrium quantity and prices :

$$q^* = \frac{\theta - F}{2\theta + \theta^{a+1}} \tag{33}$$

$$P_p = q^*\theta^{a+1} + F = \frac{\theta^{a+1} + 2F}{2 + \theta^a} \tag{34}$$

$$P_c = \theta(1 - q^*) = \frac{\theta + \theta^{a+1} + F}{2 + \theta^a} \tag{35}$$

The surplus of producers, consumers and the intermediary can be calculated for each case by :

$$\text{Producer surplus} = \frac{(P_p - F)q}{2} \tag{36}$$

$$\text{Consumer surplus} = \frac{(\theta - P_c)q}{2} \tag{37}$$

$$\text{Surplus intermediary} = (P_c - P_p)q \tag{38}$$