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Essays on quality assurance mechanisms

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Acknowledgments

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Introduction

This dissertation studies quality assurance mechanisms that exist on markets where goods with some unobservable, yet relevant characteristics are being traded. The research questions in all three chapters are inspired by existing mechanisms. I focus on certification, a mechanism based on a third party who tests producers and issues, for a fee, a certificate to those who meet the required quality standard. I also study self-regulation, where producers, rather than relying on a certifier, form a club, set standards, and monitor each other. Instead of a certificate, they use the membership label to inform consumers.

The first chapter is, to the best of my knowledge, one of the first attempts to theoretically compare certification and self-regulation. The motivation comes from the need to understand why we often see self-regulation in some industries, but certification in others. In some cases (charities, for example), one may even find the same industry self-regulated in one country but certified in another. Another puzzle that motivates this study comes from the empirical evaluation of average quality in self-regulated/certified industries. Predictions from previous theoretical models (such as Shaked and Sutton, 1981) that self-regulation leads to a reduction in the number of producers, an increase in prices due to the higher market power of the remaining producers, and an increase in quality standards, was not confirmed empirically. In fact, almost all studies reviewed by Kleiner (2006) found no increase in average quality in services provided by self-regulated professions when compared to certification, and even those few that did find an increase in average quality also found an increase in prices significantly larger than the increase in average quality. This discrepancy between theoretical and empirical observations could be explain by a specific assumption—the fixed distribution of the quality of producers, which was incorporated into the previous models.

In contrast, I assume that the quality is a choice—both for the regulatory organization (a certifier or a self-regulatory club) and the producers. The size of the organization is not directly tied to the standards as in previous models. Thus, self-regulation may, in principle, lead to the same standards as certification, in equilibrium. I find that when regulatory organizations have access to perfect and costless testing technology, self-regulation leads to better results in terms of overall welfare, even though not necessarily higher average quality. This result seems to favor self-regulation over certification despite (possibly) no improvement in average quality. However, the testing technology is generally imperfect and expensive, and it is not clear whether this result holds when the assumption about the testing technology is relaxed. Some research (Nunez 2001, 2007) seems to suggest that self-regulation is particularly vulnerable to internal problems and the enforcement of quality standards. Since imperfect testing technology cannot be incorporated into my model, I provide conjectures about its possible impact on the results reported here.

The second chapter, a joint work with Tomáš Konečný, studies a Fair Trade labelling scheme. The Fair Trade organization stipulates several requirements for certified commodities

(e.g., coffee) which their producers (farmers) and especially traders must fulfill to qualify for the label. These conditions, such as a minimal price for the farmers, pre-financing and investment into local communities, were allegedly designed to primarily benefit farmers in developing countries. However, as the number of commodities and amounts traded grow, questions about the Fair Trade (FT) rationale have been asked. It is disputed, for example, what impact FT has on non-participating farmers and what the consequences of the minimal guaranteed price are.

We build a formal model to investigate these questions. We show that the FT scheme without the price guarantee (but with other benefits to the farmers) is beneficial if it increases the total amount of the commodity traded. Introducing the price guarantee does not benefit any farmers but it may increase participation in FT in case non-participating farmers are facing a local monopsonist.[1]

The third chapter is motivated by a form of regulation of "organic" (in the USA) or "bio" (in the EU) food. A product may be sold as organic only if its producer is certified by an accredited certifier. However, consumers typically learn only that the product is certified, not by whom. Even though consumers may, in principle, learn who the certifier is, it is difficult to establish a reputation for each of them, since there are a large number of them (e.g., there are 55 certifiers in the USA only). This regulatory structure seems to be motivated by the argument that competition between certifiers lowers the price of certification, which will eventually lower the prices of organic food and will benefit the consumers.

There are two reasons why this logic is likely to be invalid. First, as was already shown (Strausz, 2004), the high price of certification guarantees honesty of the certifier. When certification fees are low, the certifier may find it more profitable to accept a bribe from a producer instead of honestly revealing the truth. Second, the certification fee might affect the entry decisions of the producers. I show in a formal model that depending on the quality of the testing technology, inexpensive certification may attract low-quality producers. To guarantee that only high-quality producers (ie., those who are indeed producing organic goods) are present on the market, a sufficiently high fee is necessary. This fee is decreasing in the quality of testing. I also show that welfare is maximized in the separating equilibrium (ie., when only high-quality producers are obtaining the certificate). A monopoly certifier would choose fee too high, yet severe competition may lead to too low fees. These results thus should serve as a warning. Introducing a large number of certifiers may lower the certification fee but it may also lead to low-quality certifiers obtaining a certificate and thus "spoiling" the pool of organic products for consumers.

All three chapters, while while being motivated by anecdotal evidence and available empirical evidence, present theoretical models attempting to understand in more detail various certification and self-regulatory systems. Due to globalization and the lengthening of supply chains, there is an increasing number of characteristics that are not observable to those who are purchasing the good. Certification and self-regulation may be effectively used to overcome trust issues when other mechanisms like repeated purchases or warranties are not available or relevant. A deeper understanding of the properties of certification and self-regulation is necessary for successful regulation and governmental oversight of the testing agencies.

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[1]The commodity that motivates our study in particular is Fair Trade coffee. It is often the case that coffee farmers are locally isolated and unable to find alternative middlemen and thus have to sell to the local trader, who thus is in the monopsonistic position.

Chapter 1

Comparing Certification and Self-regulation

Abstract:

I compare certification and self-regulation, two widely used quality assurance mechanisms in markets where consumers do not observe the quality of goods. Certification is a mechanism in which an external firm offers a certificate to producers who undergo a testing procedure, issues the certificate if they meet the certifier's standards and collects the certification fee. Self-regulation is a mechanism in which a club of firms in the industry adhere (or not) to a self-imposed code of conduct and benefit from the club's reputation. I show that if the testing technology is perfect and costless, the choice of standards and fees by the certifying organization (CO) is welfare inferior, while the self-regulatory organization (SRO) chooses a welfare optimal fee, and I identify conditions under which the SRO also chooses optimal standards. If the testing technology is costly and imperfect, this result is not necessarily valid and depends on the difference between the costs of the testing technology available to the CO and SRO.

1.1   Introduction

I study markets in which producers have a choice over the quality they produce, but this quality is unobservable for consumers. This asymmetry of information often leads to an adverse market outcome such as only low-quality products being traded even if high quality is valued by the consumers (Akerlof, 1970 and Leland, 1979). There are several mechanisms to prevent such adverse outcomes. These mechanism are, among others, producer's reputation (via repeated interaction), advertising, warranties, certification, and self-regulation.

When the information asymmetries are particularly severe,[1] certification and self-regulation often seem to work better than other mechanisms, at least theoretically. This is so because both of these mechanisms are based on a third party—an organization whose reputation replaces the need for individual reputation building by each producer, which simplifies learning for consumers. This organization must be able to observe the (signal of) quality itself. In the case of certification, such an organization is an external, possibly but not necessarily profit-maximizing, firm. In the case of self-regulation, the organization is formed by a group of producers in the industry. Typically, such an organization sets some quality standard q_S and a fee for testing the producer. When a producer applies for a certificate/membership, it pays the fee, the quality of its products is inspected and if it meets the quality standards, he is allowed to use the certificate or have the membership. The mechanisms with which a single organization's reputation may replace individual reputations is described in papers by Biglaiser and Friedman (1994) and Biglaiser (1993). Even though the honesty of this organization cannot be taken for granted (see Strausz, 2005 for certification and Nunez, 2001 for self-regulation), both mechanisms are widely used as a means of quality assurance for many professions like doctors, lawyers and accountants (Kleiner, 2006), environmental aspects of many industries (Podhorsky, 2006) and charities (Ortmann, Svitkova, and Krnacova, 2005).

Even though the honesty of a single organization, such as a certifier or a self-regulating organization, is easier to sustain, this organization may use its monopoly position to extract rents (see Shaked and Sutton, 1981 and Lizzeri, 1999 for theoretical arguments). Presumably, the rent-extraction motive might be stronger in the case of a self-regulatory organization (SRO), because such an organization sets standards to benefit its members. Yet, I show that such intuition may be wrong. The profit maximizing CO aims to extract rents from producers who in turn try to extract rents from consumers. These distortions may be larger than those caused by self-regulation.

There is empirical evidence that when the regulation of an industry is changed from certification to self-regulation, the average quality of goods may increase only slightly, if at all (Kleiner, 2006). This evidence is sometimes used to argue that self-regulation is not a better form of regulation than certification (ibid.). I show formally that such reasoning is misleading, because enforcing high quality may be inefficient when consumers' valuation of a marginal increase in quality is smaller than the marginal costs required to produce it. Thus, higher standards do not necessarily translate into higher welfare. Comparison of certification and self-regulation thus must be based on welfare, which depends on both prices and quality standards, not just the latter.

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[1]Examples include situations where there are many producers and consumers who shop infrequently so that they cannot establish individual reputations; when warranties do not work due to the moral hazard, etc. One can think of charities (a large number of various charities with quality unobservable before or after the donation), organic farmers, and also lawyers, dentists and other doctors; see Ortmann, Svitkova, and Krnacova (2005), Kleiner (2006), Shaked and Sutton (1981).

I argue that although certification and self-regulation are very similar,[2] the main difference comes from the different objectives of the CO and SRO. While certifying organizations are firms not directly linked with the producers, the self-regulatory organizations are formed by groups of producers and the SROs themselves do not generate any profit but they are motivated by profits of its members. I focus on how this difference in objectives impacts the choice of standards and the fees. I show that because the SRO itself does not aim at extracting rent from the producers, it chooses a lower fee than a profit-maximizing CO.

Since certifiers are often not-for-profit organizations, I extend the model to analyze other objective functions. In particular, I study the cases when certifiers maximize revenue of producers, number of certified producers, or standards. I also analyze the behavior of the SRO in the case when it can directly limit the number of members.[3]

These results are based on two related key assumptions. First, I assume that the testing technology is perfect. This assumption greatly simplifies the analysis but may introduce a bias in favor of one of the institutions. If the internal incentive structure in the presence of imperfect testing technology makes it more difficult for the SRO to enforce high quality standards (see Nunez, 2001 and 2007) in contrast to certification (De and Nabar, 1991), then the benefits of self-regulation may completely disappear. One thus may expect self-regulation to work better and to be more prevalent in industries where quality is easier for experts to observe, while one may expect certification in industries where quality evaluation is more difficult. In the concluding section, I also discuss the possibility to model the differences in standards enforcement as differences in costs.

This analysis applies to a variety of professions and industries. In many countries, lawyers, doctors, dentists, accountants and architects are self-regulated (Kleiner, 2006). Certification is widely used in non-profit sectors, such as hospitals and charities (Ortmann, Svitkova, and Krnacova, 2005). It is also used by for-profit firms to document environmental aspect of production (Podhorsky, 2006) and by professionals to prove expertise in the industry (Financial Risk Manager, Microsoft Certified Professional and many others). While it seems that if one industry or profession is self-regulated in one country, it will be self-regulated in other countries (typically true for lawyers, doctors and accountants), there certainly are exceptions. For example, charities are mostly certified throughout Western Europe and the USA, yet there exists a self-regulatory organization of charities in the Czech Republic. Also, as Kleiner (2006) documents, it is not unusual to find a change in the form of regulation from certification to self-regulation. This paper is a first step towards understanding these differences and explaining why certain industries are persistently self-regulated or certified.

The next section briefly reviews the literature and the basic assumptions of the model. The third section provides the model and its analysis. Next, I discuss the impact of my assumptions on the result and possible extensions and suggestions for future research. The final section concludes. Most of the proofs are provided in the Appendix.

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[2]In both cases, the consumers observe a single message (label of membership or certificate) and face in principle the same information asymmetry; producers can choose their quality and whether they will apply for a certificate or membership. The producers also have the same incentives to "cheat"—obtain a certificate of a quality they do not produce.

[3]In many countries, anti-trust regulations allow quality standards (e.g., difficulty of tests, length of supervised practice), but often do not allow direct regulation of the number of members in the organization. As there are exceptions to this rule (e.g., notaries in some countries), I analyze the impact of such regulations.

1.2   Certification and Self-Regulation

I generalize the model of self-regulation by Shaked and Sutton (1981). They construct a model of self-regulation in which the quality produced by each potential producer and the distribution of producers is fixed. This allows them to focus on the incentives of the SRO to choose minimal standards without imposing a specific objective function of the self-regulatory organization (SRO). However, the fixed distribution of potential producers implies that the SRO may improve its standards only by restricting its size. Instead, I analyze a model in which quality produced and standards are choice variables.

Such simplifying assumptions allows me to focus on the incentives of the SRO/CO to set standards without a direct link between quality and number of producers. This generalization has its cost: I need to assume an objective function. Since the SRO is formed and managed as a non–profit organization by its for-profit members, I assume that the SRO maximizes the total profit of its members.[4]

This approach differs from other papers on self-regulation. Nunez (2001) and Nunez (2007) assume that the SRO cares about its own reputation and possible bribes. He assumes that the SRO has a fixed size and pre-determined standards. Its members decide on the individual extent of cheating and the regulatory organization decides on the level of enforcement and whether to inform consumers if it finds cheating. The analysis thus focuses on the enforcement of standards and not on how standards are established. If revealed cheating reduces the reputation of the SRO enough, then the SRO does not have sufficient incentives to monitor its members and thus they are cheating in equilibrium. If a revelation of cheating increases the value of the SRO's reputation, then there exists an equilibrium with a positive level of enforcement and revelation. In addition, if a member may bribe the SRO to not reveal cheating, there exists an additional, welfare suboptimal equilibrium in which the SRO enforces the standards but does not reveal the cheating and collects bribes.[5]

This analysis suggests that the SRO is likely to suffer from internal incentive problems that prevents it from fully enforcing the standards. However, this result is based on the assumption that the SRO is motivated by the value of its reputation. If the SRO is motivated by the profits of its members, it has stronger incentives to enforce the standard, when the profits of its members depend on it. I focus on the case when the SRO (and also CO) has access to perfect testing technology.[6] Such an assumption greatly simplifies the analysis but also reduces the impact of the internal structure on quality standards. The results thus obtained may be sensitive to this assumption and in the concluding section, I discuss how the results would change if this assumption would be relaxed.

The idea of comparing certification and self-regulation is new in the literature. There is one notable exception: Shapiro (1986). He focuses on input regulation when higher initial investment makes production of high quality cheaper. He compares licensing (similar to self-regulation in our terminology), a requirement to make a minimal investment with certification, an informational device that reveals investment to the consumers but does not regulate it. Shapiro shows that licensing and certification benefit high valuation consumers at the expense

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[4]This is not the only option but it seems the most natural one. Other options are discussed in the section below.

[5]The outcome depends on the parametrization. For a summary of the results, see p. 225 of Nunez (2007).

[6]This assumption requires that the CO or the SRO is able to tell whether a product meets requires standards. This is somewhat weaker than the assumptions of other authors (such as Lizzeri, 1999) that require that the organization is able to tell the level of quality exactly.

of low valuation consumers. Shapiro assumes that the consumers are eventually able to learn the true quality of the products, so even *laissez-faire* allows some high quality production, and certification may be welfare worsening because it leads to excessive investment (because it is used as a signaling device). In Shapiro's model, there are only two levels of quality, high and low, and these levels are exogenously given. My model is more general: there will still be only two levels of quality traded on the market, but those levels will be endogenously determined. The model also differs in the assumption about the ability of consumers to learn the true quality. I assume that an individual producer's quality is completely unobservable.

I analyze the case where there exists only one signal of quality to the consumers—membership in a SRO or a certificate from a CO. This structure is very common (Kleiner, 2006; Lizzeri, 1999; Svitkova and Ortmann, 2006)) but theoretically puzzling because the certifier (or the SRO) learns more than only whether the producer meets the standard. Lizzeri (1999) shows that it is optimal for a profit-maximizing certifier to reveal only a "pass/fail" signal. In his model, the quality of a product is exogenously given in each period and a certifier learns the quality perfectly. Among all possible disclosure rules, the "pass/fail" rule is the most profitable one if the quality may have negative value to consumers. If even the expected value of quality is negative for the consumer, "pass/fail" is the only optimal rule.

The model by Biglaiser and Friedman (1994) shows that the informational advantage of a certifier (middleman in their terminology) does not need to come from perfect testing technology, but from his ability to aggregate information from consumers and using this information to "drop" (remove the certificate) from producers who attempt to cheat in quality.

1.3 Model

I model certification and self-regulation as a game with three groups of heterogeneous players: consumers, producers and either a certifying or self-regulatory organization (CO/SRO). I generalize previous models of certification by assuming that the quality of production can be of any value from zero to infinity. I study the case in which consumers cannot observe any information about a producer's quality (no individual reputation), but they know the average quality of certified products.

I assume that the certifying or self-regulatory organization has access to costless perfect testing technology[7] and sets standards to $q_S \in \mathbb{R}, q_S \geq 0$. Observing this standard, producers face a choice between producing zero quality (without a certificate) and quality q_S and applying for a certificate. Thus, similarly to previous research, producers face a binary choice between high (q_s) and low (0) quality,[8] but, in contrast to the previous literature, the levels of quality are endogenously determined. This allows us to compare not only the fees the CO/SRO will charge, but also the quality standards they will select and enforce. Note that there will be only two qualities traded on the market (q_S for certified products and 0 for not certified). Moreover, I analyze equilibria in which consumers' expectations about q_S are

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[7]I analyze the case of costly, but still perfect, testing technology in one of the extensions.

[8]Two assumptions imply that a producer will not produce any other quality than 0 or q_S in equilibrium. First, perfect detection technology means that the certifier does not make mistakes when it evaluates whether a product is of at least standardized quality. Second, there are no individual reputations of producers.

Relaxing each of these assumptions is likely to lead to a dispersion of quality. For example, in the case of imperfect testing technology, low-cost firms might produce quality higher than required because it increases the probability of passing noisy tests. High-cost firms might under-invest into quality hoping that they will pass nonetheless. It is not clear what will be the overall impact on the average quality.

fulfilled (rational expectations equilibria).

Apart from the endogenous quality and perfect testing technology, I make the following assumptions. There is a large number of heterogeneous firms,[9] each characterized by a cost parameter $\alpha_i \in [0, \infty)$; their density is described by a continuous function $f(\alpha)$ and their distribution by $F(\alpha)$. Each firm has an opportunity to produce one unit of output at quality q and at costs $g(q, \alpha)$. The cost function $g(q, a)$ is assumed to satisfy

$$g(0,0) = g_q(0,0) = g_\alpha(0,0) = 0, g(q, \alpha) > 0,$$
$$g_q(q, \alpha) > 0, g_\alpha(q, \alpha) > 0, g_{q\alpha}(q, a) > 0, g_{qq} > 0 \text{ for } q > 0, \alpha > 0,$$

where q is a non-negative real number. These assumptions mean that it is costless to produce zero quality and that the costs are increasing in quality q and cost type α. Moreover, the costs are assumed to be convex in the quality and an increase in the standard increases the costs of high-α (high-cost) producers more than it does for low-α producers. The convexity of the cost function reflects the assumption that it is increasingly costly to produce higher quality.

Due to the perfect testing technology, only firms that produce standards q_S can successfully pass the test and thus only they can sell their product with the "label" of the CO/SRO. Products without a "label" are (perceived by consumers as being) of zero quality and are sold on a separate market.[10]

Formally, the game has two stages.

1. In the first stage, a CO or SRO publicly announces standards q_S and fee C to maximize its profit (CO) or the total profit of its members (SRO).

2. In the second stage, consumers decide whether to purchase from a certified producer, taking price p and expected quality q as given. Simultaneously, firms choose how much to invest into quality, taking price p, fee C and standards q_S as given and whether to apply for a certificate. Price p is set competitively.

1.3.1   Producers and consumers

Since every producer (with cost parameter α) has a zero outside option, he will invest into quality and certification if and only if

$$p - C - g(q, \alpha) \geq 0,$$

which implies, due to our assumptions on g, the existence of a unique value of parameter $\tilde{\alpha}(C, q_S, p)$ such that only producers with $\alpha \leq \tilde{\alpha}(C, q_S, p)$ will apply for a certificate, each investing $g(q_S, \alpha)$.

There is a large number of consumers, each willing to buy up to one unit of good. Their utility depends on the expected[11] quality q, price p, their budget M and individual preference

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[9]Each firm thus has insignificant impact on the market and therefore can take market price, quality and other characteristics as not depending on its own decisions. This also justifies the assumption that producers do not have individual reputations.

[10]The zero-quality segment of the market can be interpreted in two ways. First, the certification/self-regulation can be interpreted as voluntary, and zero-quality segment is a competitive, unregulated market where producers do not invest into quality. The competitive nature of the market prevents them from making any profit. Second, certification/self-regulation may be obligatory and producers who do not apply for a certificate/membership are prevented from operating on the market and thus make zero profit.

[11]Formally, I analyze a rational expectations equilibrium in which quality expectations are fulfilled.

for quality β, which is distributed according to the continuous density function $w(\beta)$ and distribution function $W(\beta)$. The consumers can be described by a utility function $U(\beta, M, q)$, where β is the parameter describing the consumer, M is his wealth and q is the quality of the good consumed (zero if no good is purchased on this market). It is assumed that the function U is continuously differentiable in all its variables. A consumer will prefer a certified product of expected quality q and of price p if

$$U(\beta, M - p, q) \geq U(\beta, M, 0), \beta \in [0, 1].$$

Consumers prefer to have more money rather than less money ($U_M \geq 0$), they value quality ($U_q \geq 0$) and consumers with higher β value quality less than those with lower β (ie., $U_\beta \leq 0$).[12] Thus, there exists a single consumer who is indifferent between buying at price p and expected quality q, whom we will denote $\tilde{\beta}(p, q_S)$. Consumers with $\beta \leq \tilde{\beta}(p, q_S)$ demand one unit of good of quality $q > 0$, while others do not buy anything.

I will assume that there exists a market equilibrium in which supply is equal to the demand, at least for some range of quality standards[13] $q_S \in [0, \bar{q}_S]$

$$\int_0^{\tilde{\beta}(p, q_S)} w(\beta) d\beta = \int_0^{\tilde{\alpha}(C, q_S, p)} f(\alpha) d\alpha \implies p^*(C, q_S).$$

This equilibrium condition determines price $p^*(C, q_S)$. For further analysis, I will use the "reduced-forms" of functions $\tilde{\alpha}, \tilde{\beta}$, which are denoted by α^*, β^* and defined as

$$\alpha^*(C, q_S) = \tilde{\alpha}(C, q_S, p^*(C, q_S)), \ \beta^*(C, q_S) = \tilde{\beta}(p^*(C, q_S), q_S).$$

The second stage of the game thus determines price $p^*(C, q_S)$ and quantity $F(\alpha^*(C, q_S)) = W(\beta^*(C, q_S))$ as a function of the standards q_S and fee C set in the first stage. Analysis of the impact of the first stage on the equilibrium levels of prices, supply and demand is summarized in the following lemma.

Lemma 1.1 *An increase in fee C increases equilibrium prices but reduces supply and demand.*

$$1 > \frac{\partial p^*(C, q_S)}{\partial C} > 0, \frac{\partial \alpha^*(C, q_S)}{\partial C} < 0, \frac{\partial \beta^*(C, q_S)}{\partial C} < 0$$

An increase in standards q_S always increases the equilibrium price $\frac{\partial p^*(C, q_S)}{\partial q_S} > 0$, but leads to a decrease in demand and supply if and only if

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}(\beta, M - p^*(C, q_S), q_S)}{U_M(\beta, M - p^*(C, q_S), q_S)}.$$

Proof of this lemma is provided in the Appendix and uses comparative statics with respect to q_S and C. The result is intuitive: an increase in the cost of certification C translates into an increase in the price of products p^*, but fewer products are traded because the higher price

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[12]I will assume that the inequalities are strict for $q > 0$. Moreover, I will assume that $U_\beta(\beta, M, 0) = 0$ because it simplifies the results without any significant loss of generality. Note that the more usual assumption $U_{\beta q} < 0$ for $q > 0$ implies that $U_\beta < 0$, and thus would also be sufficient for the results.

[13]Further assumptions about g are necessary to show that there exists the highest possible quality traded $\bar{q}_s$. These conditions are derived in section 3.5.1, where the behavior of the standard maximizing non-profit certifier is analyzed.

reduces demand for certified products. The overall impact on the supply is negative because the price increases less than fee C does and thus overall revenue for the firm $p - C$ decreases, which also decreases the supply. Further, an increase in the standards increases the value of the product for the consumer and costs to the firms and leads to an increase in price p. The impact of an increase in standards on supply and demand can be intuitively seen when the condition is rewritten as[14]

$$g_{q_S}(q_S, \alpha^*(C, q_S))U_M > U_{q_S}.$$

In this form, the left-hand side describes the marginal costs (in utility terms) of an increase in standards while the right-hand side describes the benefit it has for the consumers. If the marginal consumers' benefit is higher than the marginal cost, an increase in standards generates a positive surplus, which allows further trade and increases equilibrium demand and supply.

1.3.2   Behavior of the certifier

In the first stage of the game, the organization chooses the standard q_S and fee C. I first focus on the behavior of a profit-maximizing certifier. In Section 1.3.5, I extend our analysis by analyzing alternative objective functions.

Profit-maximizing certifier

When the testing technology is costless, the objective function of the profit-maximizing certifier is

$$\max_{C, q_S} C \int_0^{\alpha^*(q_s, C)} f(\alpha)d\alpha = \max_{C, q_S} CF(\alpha^*(q_S, C)).$$

The optimal interior choice of standard q_S and certification fee C is thus described by the first order conditions

$$[C] \quad : \quad F(\alpha^*(C, q_S)) + Cf(\alpha^*(C, q_S))\frac{\partial \alpha^*(C, q_S)}{\partial C} = 0,$$

$$[q_S] \quad : \quad Cf(\alpha^*(C, q_S))\frac{\partial \alpha^*(C, q_S)}{\partial q_S} = 0.$$

I assume that there exists an interior solution, which is a maximum.[15]

Lemma 1.2 *In equilibrium, I have*

$$g_{q_S}(q_S, \alpha^*(C, q_S)) = \frac{U_{q_S}}{U_M}$$

and

$$\frac{\partial p^*(C, q_S)}{\partial q_S} = \frac{U_{q_S}}{U_M}, \frac{\partial \alpha^*(C, q_S)}{\partial q_S} = \frac{\partial \beta^*(C, q_S)}{\partial q_S} = 0.$$

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[14]For simplicity, I often write U instead of $U(\beta, M - p^*(C, q_S), q_S)$, where the arguments are obvious.

[15]To prove that the solution is a maximum, one would need to verify the definiteness of the matrix of second order conditions. Given that the expression for α is endogenously based on consumer preferences and production costs, this would be quite technical. However, from the economical point of view, assuming the existence of a solution seems reasonable.

These conditions are intuitive—the profit maximizing behavior of the CO chooses standards so that the increase in costs for a marginal producer equals the increase in price. Other certified producers are not relevant for the decision made by certifiers because they make positive profits. Also, standards are chosen so that the maximum number of producers applies for certification, given the fee C.

Overall, the certifier's choice of certification fee and standards can be separated into two hypothetical parts. First, for any given certification fee C, the certifier chooses standards so that the maximum number of producers applies:

$$\frac{\partial \alpha^*(C, q_S)}{\partial q_S} = 0.$$

Given the relationship between the certification fee and the number of producers applying for certification, it then chooses the optimal fee C. This result will be useful later because it describes the optimal standards even for exogenously given fees C.

1.3.3 Behavior of the self-regulatory organization

I analyze the behavior of a self-regulatory organization (SRO) formed by firms in the industry that sets standards to maximize the total profit of its members.[16] The SRO can reject or accept its members depending only on their quality of production.[17] This allows the SRO to choose its size by choosing the standards, but not directly. If the SRO maximizes the total profit of its members, it does not need to charge any fee C, but sets only some standards q_S in order to maximize its profit. Charging positive fees that are then returned to the members of the organization would not change their behavior and would not affect the results.

Quality restrictions only

Without adding any technical complications, I can analyze a more general problem when the SRO charges a positive fee C, but the money thus collected belongs to the government. The problem for the SRO that charges an exogenously given fee C and tries to choose standards so that it maximizes the profit of its members is

$$\max_{q_S} \int_0^{\alpha^*(C, q_S)} \left(p(C, q_S) - g(q_S, \alpha) - C \right) f(\alpha) d\alpha.$$

The first order condition is[18]

$$\int_0^{\alpha^*(C, q_S)} \left(\frac{\partial p(C, q_S)}{\partial q_S} - \frac{\partial g(q_S, \alpha)}{\partial q_S} \right) f(\alpha) d\alpha = 0.$$

---

[16]In general, these organizations set the quality standards based on the preferences of their members. This leads to some ambiguity in their objective function, since the SROs themselves have not-for-profit status. Thus, the question is whether the SRO maximizes the profits of their highest/lowest quality members, the average profit, the total profit, or something else. I start with probably the most realistic and simplest approach of total profit maximization. Other approaches often lead to corner solutions. For example, maximizing average profit immediately leads to a zero-size SRO with only the highest quality (lowest costs of quality) firms, unless there are economically significant fixed costs.

[17]This means that the SRO has to accept an application from any firm that meets the required standard. It also implies that the (only) punishment for not meeting the required standards is exclusion from the organization.

[18]It is easy to see that there is an interior solution. Clearly, a zero standard implies zero total profit. Also, a very large standard implies costs larger than the price if the consumers' valuation of quality is bounded from above.

Since the term $\frac{\partial p(C, q_S)}{\partial q_S}$ does not depend on α, the equilibrium conditions can be written as

$$F(\alpha^*(C, q_S))\frac{\partial p(C, q_S)}{\partial q_S} = \int_0^{\alpha^*(C, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S}f(\alpha)d\alpha.$$

Lemma 1.3 *If $\frac{\partial^2 g(q_S, \alpha)}{\partial \alpha \partial q_S} > 0$, then in the interior solution the SRO chooses standards such that the marginal costs for a marginal firm (α^*) of its members exceed the relative valuation of the marginal consumer:*

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}}{U_M}.$$

The intuition is that producers with $\alpha < \alpha^*$ face lower increases in the costs of production but the same increase in price. Therefore, the SRO chooses standards higher than those that would equalize the marginal cost and revenue for marginal producer α^* because such standards would leave "money on the table"—an increase in standards would increase revenues more than the costs for all producers. Note that this result holds for any C.

Quality and quantity restrictions

I extend the previous analysis by considering an alternative form of regulation, under which the SRO is able to restrict the number of its members. This contrasts two possible forms of regulation of the SRO. In the previous case, the SRO was free to choose standards q_S, but it had to admit every producer who was able to meet this standard. Alternatively, the SRO might be given the right to select the number of members. In the first case, the marginal producer will have zero profit. In the second case, even marginal (the highest-cost) member may be making a positive profit.

Since

$$\frac{\partial \alpha^*(C, q_S)}{\partial C} < 0,$$

the function $n = \alpha(C, q_S)$ is invertible in C. Thus, by controlling the minimum profit its members must make, the SRO is able to control the number of members. In such a situation, the total profit-maximizing organization will have the following objective function:

$$\max_{q_S, C} \int_0^{\alpha^*(C, q_S)} \left(p(C, q_S) - g(q_S, \alpha)\right) f(\alpha)d\alpha.$$

Lemma 1.4 *The SRO that can restrict the number of its members directly will still choose C, q_S such that*

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}}{U_M}.$$

In fact, I'm comparing standards chosen under the two regimes. The first regime is a form of regulation that requires the SRO to charge a membership fee $C > 0$ and the revenue from these fees belongs to the government. Under the second regime, the SRO enforces minimum profit $C > 0$, but does not collect any fees. In both cases, the SRO chooses standards to maximize the total profit of its members.

Proposition 1.1 *Let's assume that the first-order conditions are monotonic.*[19] *The SRO that is able to restrict the number of its members by enforcing a minimum profit constraint chooses lower quality standards than the SRO that has only quality restrictions at its disposal, for any fixed fee C.*

This result has the following intuitive explanation. Under the quality-only self-regulation, when considering an increase in quality standards q_S, the SRO takes into account only the impact on the revenues and costs of current members because marginal members make zero profit. However, under quality-and-quantity regulation, an increase in standards makes some members leave and this reduces total profit because they made positive (C) profit before the change. Thus, the marginal costs of increasing standards are higher under quality-and-quantity regulation; marginal revenues are the same and standards are therefore lower.

Direct comparison of standards between an organization charging a zero fee and a SRO that works under quality-and-quantity regulation is not possible. The reason is that the sign of $\frac{\partial q_S}{\partial C}$ is not clear. The structure of this model is general enough to allow for both a positive and negative sign of $\frac{\partial q_S}{\partial C}$, depending on consumers' valuation and the distribution of producers and consumers (see Example 1.1 in the Appendix).

1.3.4   Welfare analysis

The presence of a CO or SRO improves welfare—without these institutions, assumptions of unobservable, costly, and endogenous quality, lead to only zero quality products being traded in the equilibrium. However, since neither a profit-maximizing CO nor SRO take directly into account the impact of their choice of standards and fees on the consumers, it seems likely that neither of them leads to a welfare optimal outcome. I start the analysis with the optimal choice of fee C and standards q_S and compare this choice to the behavior of the SRO and CO. The total welfare is the sum of the profit of the CO/SRO (if any), the profit of producers and consumer surplus.

Consumer surplus

To compute the consumer surplus, I derive the demand function $W(\tilde{\beta}(p,q))$.[20] First, I find the marginal consumer $\tilde{\beta}(p,q)$ who is indifferent between buying a product of quality q and price p :

$$U(\tilde{\beta}(p,q), M - p, q) = U(\tilde{\beta}(p,q), M, 0).$$

All consumers with $\beta > \tilde{\beta}(p,q)$ prefer not to buy, while consumers $\beta \leq \tilde{\beta}(p,q)$ will buy. The demand is thus

$$W(\tilde{\beta}(p,q)) = \int_0^{\tilde{\beta}(p,q)} w(\beta)d\beta.$$

The consumer surplus is then

$$CS(p^*, q^*) = \int_{p^*}^{\infty} W(\tilde{\beta}(p,q))dp.$$

Trivially, an increase in quality q leads to an increase in consumer surplus if the price remains constant.

---

[19]This assumption is trivial in the case when there is a unique local optimum.

[20]In this section, I use again $\tilde{\beta}(p,q)$ instead of $\beta^*(C, q_S)$ as I analyze the consumer surplus that depends on prices and quality.

Total welfare

Using the previous definition of consumers' surplus, I can define total welfare as the sum of the profit of the certifier, firms and consumer surplus:

$$W \ = \ CF(\alpha^*(C, q_S)) + \int_{p^*(C, q_S)}^{\infty} W(\tilde{\beta}(p, q_S))dp +$$

$$+ \int_0^{\alpha^*(C, q_S)} (p^*(C, q_S) - g(q_S, \alpha) - C) f(\alpha)d\alpha.$$

Since the certification fee C is a pure transfer that restricts supply and demand even in the situation where there would be space for trade at zero fee, one can easily show that the welfare is optimal when the fee is equal to $C = 0$.

Proposition 1.2 *Welfare optimum is reached at the point where $C = 0$.*

Two conditions will be useful for the following analysis. The first condition holds when marginal costs increase more than utility as a result of a marginal increase in standards in equilibrium.

Condition 1.1

$$\frac{d}{dq_S}g_{q_S}(q_S, \alpha^*(q_S, C)) > \frac{d}{dq_S}\frac{U_{q_S}}{U_M}$$

This condition is endogenous in this model, because it does not depend only on the primitives of the model, but on α^* and β^* as well. Given the general structure of the model, it is not possible to derive an exogenous condition, except for a specific, numeric examples.[21] However, one can gain additional insight under some assumptions. For example, if one assumes that the marginal value of money is constant $U_M = c > 0$, i.e. in the case of quasilinear utility functions, it can be easily shown that Condition 1.1 is equivalent to

$$g_{q_S^2} + g_{q_S\alpha}\frac{\partial \alpha^*}{\partial q_S} > \frac{1}{U_M}\left(U_{q_S^2} + U_{q_S\beta}\frac{\partial \beta^*}{\partial q_S} - U_{q_SM}\left(\frac{\partial p}{\partial q_S}\right)\right).$$

This can be rewritten as

$$g_{q_S^2} - \frac{U_{q_S^2}}{U_M} + g_{q_S\alpha}\frac{\partial \alpha^*}{\partial q_S} - \frac{U_{q_S\beta}}{U_M}\frac{\partial \beta^*}{\partial q_S} > -\frac{U_{q_SM}}{U_M}\left(\frac{\partial p}{\partial q_S}\right).$$

The first two terms on the left hand side represent the monetary value of the difference between an increase in marginal costs and marginal valuation due to a marginal increase in the quality. The second two terms represent the change of these costs due to a change in the supply and demand. The expression on the right hand side would represent a change in the marginal value of money due to a change in standards, but under the assumption that U_M is constant, it is zero. Thus, Condition 1.1 is essentially equivalent to the requirement that the marginal costs of producing quality are increasing faster than the marginal valuation of quality.

Note that there are two competing effects in play. First, a simple increase in quality increases costs and decreases the marginal value of the good. Second, an increase in quality

---

[21]This may be considered an advantage. The condition depends on the structure of the consumer/producer market and provides insight regardless of the specific structure of this market.

drives some producers and consumers out (α^*, β^* decrease), which increases the marginal value of the good and decreases the marginal costs of producing, since the remaining consumers value the goods more and the remaining producers are able to make the good at lower costs. Condition 1.1 requires that the first effect is stronger then the second one: marginal costs are increasing fast enough when the required quality increases.

The second condition holds if producers appropriate less than the marginal change in consumer surplus when standards marginally change.

Condition 1.2

$$F(\alpha^*(C, q^{CO}))\frac{\partial p(C, q^{CO})}{\partial q_S} < \int_{p^*(C, q_S)}^{\infty} w(\tilde{\beta}(p, q^{CO}))\frac{\partial \tilde{\beta}(p, q^{CO})}{\partial q}dp$$

Note that since this condition characterizes only marginal effects, it is theoretically possible that the condition does not hold: when standards change, the profit of the producers may increase more than the surplus of the consumers. Again, this condition is endogenous in this model. The condition holds if consumers (and thus also demand) is insensitive to the changes in standards, while costs and then also prices are sensitive.

The comparison of standards and welfare

Even though the SRO chooses zero fee C, one cannot in general expect its choice of quality standard q_S to be welfare-optimal because it only maximizes the profit of its members. I confirm this intuition by showing that only when the SRO can fully extract a marginal increase in consumer surplus due to an increase in standards, will the choice of standard be welfare-optimal.

Proposition 1.3 *The standards chosen by the SRO charging zero fee, $C = 0$, are welfare optimal only if the producers are able to fully appropriate the marginal increase in consumer surplus in equilibrium, i.e., when Condition 1.2 holds with equality for $C = 0$.*

In the case the SRO is not able to do so, it will choose welfare-suboptimal standards.[22] The following result shows when such standards will be lower than welfare-optimal.

Proposition 1.4 *Assume fee $C = 0$ is fixed. If Condition 1.2 holds at $q_S = q^{WO}$ and $C = 0$, and if the first order conditions for the SRO are monotonic in q_s, then $q^{SRO} < q^{WO}$ in equilibrium.*

Next, I compare standards chosen by the CO and SRO if they charge the same fee C.

Proposition 1.5 *Assume C is fixed. If and only if Condition 1.1 holds, the SRO chooses higher quality standards than the CO.*

---

[22]Note that the ability to fully extract the marginal increase does not imply the ability to extract all the surplus. It may happen that the SRO is able to extract a small portion of the surplus for very low levels of quality, but that this portion increases as the quality increases. Thus, it is even theoretically possible that the SRO is able to extract *more* than the marginal increment in the surplus.

This result does not allow us to compare standards chosen for different fees.[23] However, it is valid for all fees C, not necessarily the optimal or zero one. The proof of this result is based on the following intuition. The certifier chooses standards so that the change in costs and prices are equal to each other for the marginal producers (to maximize participation). This is suboptimal for self-regulation, because other participating producers face lower marginal costs than the marginal change in price (and revenues). Thus, the SRO chooses quality so that the marginal costs for the marginal producer are higher than the marginal revenue. Under the condition from this proposition, this happens only when standards are higher than those chosen by the CO.

Also, one can combine the previous results to compare standards chosen by the CO and welfare optimal standards.

Proposition 1.6 *Let's assume that the welfare function has only one optimum in the relevant range.[24] If Condition 1.2 holds, then the CO chooses lower standards than is welfare optimal for an exogenously given fee C.*

The result is similar to Proposition 1.4. It shows that the ability of the CO to extract rent determines the quality standards. Combining results from Propositions 1.4, 1.5 and 1.6 gives the following corollary.

Corollary 1.1 *If Conditions 1.1 and 1.2 hold for a given C, the standards satisfy*

$$q^{WO}(C) > q^{SRO}(C) > q^{CO}(C).$$

Finally, I show that a comparison of standards for different fees is not possible.

Proposition 1.7 *In equilibrium, standards chosen by a self-regulatory organization can be higher or lower than those chosen by a certifying organization.*

In the appendix, I present two examples that differ in the production costs only. In one case, the SRO chooses a higher standard than the CO, while the opposite is true in the other example. Thus, it is not possible to make a comparison of standards for different fees.

1.3.5   Extension—not-for-profit certifiers

Next, I extend the analysis by considering the behavior of not-for-profit certifiers. I focus on the maximization of revenue, standards and the number of certified firms.

---

[23]The comparison of standards for different fees is not possible because it is not clear what effect a change in fee C will have on the standards chosen by the SRO. Using the Implicit Function Theorem, one can show that such an effect is non-linear and its sign cannot be determined without significantly restrictive assumptions.

In the appendix, I show that it is possible, at $C = 0$, for the SRO to choose higher and lower standards than the standards chosen by the CO at the fee of its choice.

[24]This range is $[\min\{q^{CO}(C), q^{WO}(C)\}, \max\{q^{CO}(C), q^{WO}(C)\}]$,where $q^{WO}(C)$ is a welfare optimal standards for an exogenously given fee $C > 0$. This condition is satisfied if, for example, the welfare function is differentiable and single peaked.

Revenue maximization

Let's assume that the certifier maximizes the total revenue of the certified producers. Since producing quality is costly, this is not equivalent to the total profit-maximization of the SRO. Thus, the certifier chooses fee C and quality standards q_S to maximize

$$\max_{C,q_S} \int_0^{\alpha^*(C,q_S)} \left(p(C,q_S)\right) f(\alpha) d\alpha = \max_{C,q_S} F\left(\alpha^*(C,q_S)\right) p(C,q_S).$$

Proposition 1.8 *The producer-revenue-maximizing certifier will choose higher standards than the profit-maximizing certifier for any given C if and only if Condition 1.1 holds.*

In contrast to the profit-maximizing certifier, the producers' revenue maximization CO thus chooses higher standards for any given C.

Maximization of the number of certified producers

Let's analyze the behavior of the CO that maximizes the total number of certified organizations.

$$\max_{q_S,C} F\left(\alpha^*(C,q_S)\right)$$

It is easy to show that because increasing fee C reduces participation for given standards (Lemma 1.1), the CO maximizing the number of certified producers will choose zero fee. I compare the standards it will choose with the SRO that also prefers fee $C = 0$.

Proposition 1.9 *The optimal standards are lower than those chosen by the SRO if and only if Condition 1.1 holds.*

Note that the standards chosen by a certifier that maximizes the number of certified producers and its own profit are the same for fixed fee C. Their behavior differs in the choice of fees, not standards.

Standards maximization

Let's assume that the CO maximizes the standards, subject to participation constraints. Intuitively, zero market size is to be expected. On such a market, consumers of the highest valuation ($\beta = 0$) trade with producers with the lowest production costs ($\alpha = 0$). Obviously, the fee C is set to zero. Neither consumers nor producers have a positive surplus—the price corresponds to the production costs, which corresponds to the valuation of the good. The maximal price as a function of quality is implicitly defined by the equation

$$U(0, M - p_{\max}, q_{\max}) = U(0, M, 0).$$

The lowest price that a producer of the lowest costs is willing to accept for a good of quality $q_{\max}$ is

$$p = g(q_{\max}, 0).$$

The maximal quality that can be produced on the market is

$$U(0, M - g(q_{\max}, 0), q_{\max}) = U(0, M, 0).$$

Note that this problem may have an unbounded solution. For example, if $U_q > 0$ and $g(q,0) = g_q(q,0) = 0$, the highest possible standards are infinite.[25] Obviously, this is a degenerate case that does not require further study.

1.3.6   Extension 2—costly testing technology

So far, I have assumed that both CO and SRO possess costless and perfect testing technology. In this section I analyze the situation in which the costs of certification and self-regulation are positive. I do not assume that the costs differ between the CO and SRO, even though this is certainly possible. I postpone the discussion of the difference in the cost to the last section. I do not intend to show that certification is cheaper than self-regulation (or *vice-versa*). Instead, I study how costs influence the choice of fee and standards analyzed in the previous section. For simplicity, I study only for-profit certification and total-profit maximization self-regulation. It is obvious that purely fixed costs would not affect the decision of the CO, who needs to cover them to remain in the market. It would, however, force the SRO to charge a positive fee. Depending on the size of these costs, the SRO will behave somewhat similarly to the CO. If these fixed costs are as large as the potential profit of the profit-maximizing CO, the SRO would have to behave exactly as the CO—it is not possible to extract the same amount from the producers in another, for them preferred, way.[26]

However, it is not possible to analyze the general cost function. Instead, I focus on constant marginal cost technology—each test costs $\delta > 0$.

Total-profit-maximizing SRO

As before, I assume that the SRO charges fee C and the revenues thus collected belong to the government.

$$\max_{q_S} \int_0^{\alpha^*(C,q_S)} \left(p(C,q_S) - g(q_S,\alpha) - C \right) f(\alpha)d\alpha - \delta F(\alpha^*(C,q_S)), q_S).$$

The first order condition is

$$\int_0^{\alpha^*(C,q_S)} \left(\frac{\partial p(C,q_S)}{\partial q_S} - \frac{\partial g(q_S,\alpha)}{\partial q_S} \right) f(\alpha)d\alpha - \delta \frac{\partial \alpha^*(C,q_S)}{\partial q_S} = 0.$$

Lemma 1.1 and Lemma 1.3 show that the SRO operates in the range of standards where an additional increase in standards leads to lower participation. In the case of positive constant marginal costs, the SRO benefits more from increasing the standard because it will have to certify less producers. Thus, these costs increase the standards chosen by the SRO.

Profit-maximizing CO

The objective function of the profit-maximizing CO facing positive marginal costs δ is

$$\max_{C,q_S}(C - \delta)F(\alpha^*(q_S,C)).$$

---

[25]Note that these assumptions require $g(0,0) = g_q(0,0) = 0$, but do not specify $g_q(q,0)$ or $g(q,0)$ for $q > 0$.
[26]If there was such possibility, the CO would be able to achieve higher profits.

The first order conditions are

$$[C] \quad : \quad F(\alpha^*(C, q_S)) + (C - \delta)f(\alpha^*(C, q_S))\frac{\partial \alpha^*(C, q_S)}{\partial C} = 0,$$

$$[q_S] \quad : \quad (C - \delta)f(\alpha^*(C, q_S))\frac{\partial \alpha^*(C, q_S)}{\partial q_S} = 0.$$

One can see that the decision about q_S did not change. Compared to the costless technology case,

$$[C] : F(\alpha^*(C, q_S)) + Cf(\alpha^*(C, q_S))\frac{\partial \alpha^*(C, q_S)}{\partial C} = 0.$$

The second term in the first FOC is negative but smaller than before $(C - \delta)$, *ceteris paribus*. This implies a necessary reduction in the number of applicants $F(\alpha^*(C, q_S))$. Since the quality decision did not change, the reduction in participants comes only from an increase in fees C.

This result is not surprising in light of our previous conclusions. The CO always chooses standards so that the number of applying producers is maximized for a given fee C. Since the testing gets more expensive, the CO wants to reduce the number of applicants. The optimal way to do so is by increasing fees. This nicely contrasts with the SRO that does not increase the fees, but increases quality standards, which reduces the number of producers applying for membership.

Under fixed costs, the SRO has to charge a positive fee to cover these costs, but it chooses to charge the lowest fee possible. Fixed costs thus motivates the SRO to increase its size and this can be done only via reduced standards. Obviously, these two effects have opposite directions.

1.4 Conclusion and Discussion

In this paper, I present a unified model of certification and self-regulation and analyze its properties in order to compare the behavior of self-regulatory organizations and certifying organizations. The ability to extract marginal rents from consumers determines whether the standards of the SRO will be optimal or not. Because the welfare optimal fee is zero, the behavior of the profit-maximizing CO is never welfare optimal. I also study conditions under which the SRO is forced to charge a positive fee, $C > 0$. If the marginal production costs g_{q_S} are increasing in quality q more than the (relative) marginal consumer valuation $\frac{U_{q_S}}{U_M}$, then the SRO chooses higher quality standards. Finally, I show that under mild conditions on the welfare function, the CO will choose lower quality standards than would be welfare optimal even for any exogenously given fee $C > 0$.

All these quality comparisons are possible only under the assumption that the fees are the same. Therefore, they do not let us to compare standards actually chosen by the SRO $(C = 0)$ and CO $(C > 0)$. However, I show that the SRO may choose higher or lower quality than the CO, using two simple examples. Because the impact of an exogenously given fee on standards chosen by the SRO is ambiguous, it is not possible to identify the precise conditions that would determine whether the SRO will choose higher or lower standards in a general setting.

I also study the form of the regulation of the SRO. If the SRO is allowed to impose both quality standards and limit the number of its participants, it will choose lower quality standards than the SRO that can use only quality as a restriction of entry. This is a generalization of Shaked and Sutton (1981).

I also discuss the impact of the objective function of a certifier on the quality and fee chosen. I have shown that if Condition 1.2 holds, a CO that maximizes the revenue of producers will choose higher standards than the (its own) profit-maximizing CO. Moreover, the CO that maximizes the number of certified organizations chooses zero fee C and lower standards than the SRO, if Condition 1.1 holds. The standard-maximizing CO leads to a corner solution—one unit of good traded, and zero profit and consumer surplus.

Finally, I analyze the case of costly testing technology. If there are positive constant marginal costs, the SRO chooses higher standards, while the CO increases the fee but does not change standards.

Thus, this model provides some evidence that the SRO may often be more favorable relative to profit-maximizing certification. When the testing technology is perfect, it chooses lower fees and if it is able to fully extract marginal change in consumer surplus when standards change, it chooses optimal standards. Not-for-profit certification may be a more suitable alternative to self-regulation than a for-profit one. A certifier maximizing the number of certified producers is likely to choose lower standards but will choose an optimal fee. The certifier who maximizes producers' revenue will (under mild conditions) choose higher standards than the for-profit certifier, but will choose positive fees.

This modeling approach has several limitations. I assume perfect testing technology for the CO and SRO. This assumption significantly simplifies the analysis because it allows us to focus on one level of quality—a standard. I can abstract from the game between the SRO (who tries to establish a quality that benefits everybody) and its members (who would prefer if only others produce high quality).

It is clear that perfect detection technology does not in fact exist. Since mistakes happen, firms for whom it is cheap to produce high quality goods might prefer to over-invest to reduce the probability of an unfavorable error, while firms with high costs for producing quality goods might be willing to take some risks and under-invest in quality. This analysis does not allow us to capture these effects.

If the testing technology is imperfect, the mechanism of certification (De and Nabar, 1991) and self-regulation (Nunez 2001, 2007) work less efficiently. Some producers may be able to pass the test despite the fact that they do not meet the required standards. This has an impact on the quality expectations of consumers and thus the prices of the products and on other producers. Results by Nunez (2001,2007) seem to suggest that this impact may be particularly strong in the case of self-regulation. In such a case, this analysis is biased in favor of self-regulation. While relaxing the assumption of perfect testing technology does not seem possible due to the complexity of the resulting model, it may be possible to remove the bias by assuming more expensive testing technology for the SRO. For example, such an assumption may be justified by more expensive negotiations between various members of the SRO or by the need for higher payments to the management of the SRO to enforce the standards. Then, these results that seem to favor self-regulation may no longer be valid, depending on these additional costs for the SRO.

1.5 Appendix

Proof of Lemma 1.1. Using the defining equations of $p^*(C, q_S), \alpha^*(C, q_S), \beta^*(C, q_S)$,

$$
\begin{aligned}
F_1 \quad &: \quad p^*(C, q_S) - C - g(q_S, \alpha^*(C, q_S)) = 0, \\
F_2 \quad &: \quad \int_0^{\beta^*(C, q_S)} w(\beta)d\beta - \int_0^{\alpha^*(C, q_S)} f(\alpha)d\alpha = 0, \\
F_3 \quad &: \quad U(\beta^*(C, q_S), M - p^*(C, q_S), q_S) - U(\beta^*(C, q_S), M, 0) = 0,
\end{aligned}
$$

I compute the matrix of first derivatives and use it to do comparative statics using the Implicit Function Theorem:

$$
\begin{pmatrix}
1 & -g_\alpha(q, \alpha) & 0 \\
0 & -f(\alpha^*) & w(\beta^*) \\
-U_M & 0 & U_B
\end{pmatrix}.
$$

Using the vector

$$
\left(-\frac{\partial F_1}{\partial C}, -\frac{\partial F_2}{\partial C}, -\frac{\partial F_3}{\partial C} \right)' = (1, 0, 0)'
$$

and Cramer's rule, one gets

$$
\frac{\partial p^*(C, q_S)}{\partial C} = \frac{-f(\alpha^*)U_\beta}{-f(\alpha^*)U_\beta + U_M g_\alpha(q, \alpha)w(\beta^*)} > 0
$$

$$
\frac{\partial \alpha^*(C, q_S)}{\partial C} = \frac{-U_M w(\beta^*)}{-f(\alpha^*)U_\beta + U_M g_\alpha(q, \alpha)w(\beta^*)} < 0
$$

$$
\frac{\partial \beta^*(C, q_S)}{\partial C} = \frac{-f(\alpha^*)U_M}{-f(\alpha^*)U_\beta + U_M g_\alpha(q, \alpha)w(\beta^*)} < 0.
$$

Note that

$$
\begin{aligned}
U_\beta \quad < \quad & 0, U_M > 0, g_\alpha > 0, w(\beta^*) > 0, f(\alpha^*) \implies \\
& -f(\alpha^*)U_\beta + U_M g_\alpha(q, \alpha)w(\beta^*) > 0,
\end{aligned}
$$

and thus

$$
1 > \frac{\partial p^*(C, q_S)}{\partial C} > 0, \frac{\partial \alpha^*(C, q_S)}{\partial C} < 0, \frac{\partial \beta^*(C, q_S)}{\partial C} < 0.
$$

A similar analysis for $\frac{\partial}{\partial q_S}$ leads to

$$
\left(-\frac{\partial F_1}{\partial q_S}, -\frac{\partial F_2}{\partial q_S}, -\frac{\partial F_3}{\partial q_S} \right)' = (g_{q_S}(q_S, \alpha), 0, -U_{q_S})'.
$$

Our assumptions are

$$
g_{q_S}(q_S, \alpha) > 0, f(\alpha^*) > 0, w(\beta^*) > 0, U_\beta < 0, U_M > 0, U_q > 0,
$$

which allows me to compute the signs of partial derivatives:

$$
\frac{\partial p}{\partial q_S} = -\frac{g_{q_S}(q_S, \alpha)f(\alpha^*)U_\beta - U_{q_S}g_\alpha(q, \alpha)w(\beta^*)}{-f(\alpha^*)U_\beta + U_M g_\alpha(q, \alpha)w(\beta^*)} > 0
$$

$$\frac{\partial \alpha}{\partial q_S} = -\frac{U_M g_{q_S}(q_S, \alpha) - U_{q_S}}{-\frac{f(\alpha^*)}{w(\beta^*)} U_\beta + U_M g_\alpha(q, \alpha)}$$

$$\frac{\partial \beta}{\partial q_S} = -\frac{U_M f(\alpha^*) g_{q_S}(q_S, \alpha) - U_{q_S} f(\alpha^*)}{-f(\alpha^*) U_\beta + U_M g_\alpha(q, \alpha) w(\beta^*)}.$$

The sign of $\frac{\partial \alpha}{\partial q_S}$ and $\frac{\partial \beta}{\partial q_S}$ depend on the relative size of g_{q_S} and $\frac{U_q}{U_M}$. If the increase in costs of the marginal firm due to an increase in standards is bigger than the relative benefit to the consumers $\frac{U_q}{U_M}$, the size of the market decreases.

Proof of Lemma 1.2.   Since both C and $f(\alpha)$ are positive, the first order condition implies

$$\frac{\partial \alpha^*}{\partial q_S} = 0.$$

Using the derivations from the proof of Lemma 1.1, such a condition requires

$$U_M g_{q_S}(q_S, \alpha) - U_{q_S} = 0 \implies g_{q_S}(q_S, \alpha) = \frac{U_{q_S}}{U_M}.$$

If one plugs this result into the expression for $\frac{\partial p}{\partial q_S}$, one gets

$$\frac{\partial p}{\partial q_S} = -\frac{\frac{U_{q_S}}{U_M} f(\alpha^*) U_\beta - U_{q_S} g_\alpha(q, \alpha) w(\beta^*)}{-f(\alpha^*) U_\beta + U_M g_\alpha(q, \alpha) w(\beta^*)} = \frac{U_{q_S}}{U_M}.$$

By plugging this result into the expression for

$$\frac{\partial \beta}{\partial q_S} = -\frac{U_M \frac{U_{q_S}}{U_M} f(\alpha^*) - U_{q_S} f(\alpha^*)}{-f(\alpha^*) U_\beta + U_M g_\alpha(q, \alpha) w(\beta^*)}$$

one can obtain $\frac{\partial \beta}{\partial q_S} = 0$.

Proof of Lemma 1.3.   The first order conditions are

$$[C] \quad : \quad \int_0^{\alpha^*(C, q_S)} \frac{\partial p(C, q_S)}{\partial C} f(\alpha) d\alpha + \frac{\partial \alpha^*(C, q_S)}{\partial C} f(\alpha^*(C, q_S)) C = 0, \text{ and}$$

$$[q_S] \quad : \quad \int_0^{\alpha^*(C, q_S)} \left(\frac{\partial p(C, q_S)}{\partial q_S} - \frac{\partial g(q_S, \alpha)}{\partial q_S} \right) f(\alpha) d\alpha + \frac{\partial \alpha^*(C, q_S)}{\partial q_S} f(\alpha^*(C, q_S)) C = 0.$$

The second of these conditions is positive if

$$g_{q_S}(q_S, \alpha^*(C, q_S)) = \frac{U_{q_S}}{U_M} \iff \frac{\partial \alpha^*(C, q_S)}{\partial q_S} = 0.$$

Since

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}}{U_M} \iff \frac{\partial \alpha^*(C, q_S)}{\partial q_S} < 0,$$

and $\frac{\partial p(C, q_S)}{\partial q_S} > 0$, the equilibrium may occur only if

$$\frac{\partial p(C, q_S)}{\partial q_S} < \frac{\partial g(q_S, \alpha)}{\partial q_S},$$

which happens if and only if

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}}{U_M}.$$

Proof of Lemma 1.4. Assume the existence of an interior solution q_S such that the first order condition holds. Using a contradiction, if $g_{q_S}(q_S, \alpha^*(C, q_S)) \leq \frac{U_q}{U_M}$, then

$$F(\alpha^*(C, q_S))\frac{\partial p(C, q_S)}{\partial q_S} > \frac{\partial g(q_S, \alpha^*(C, q_S))}{\partial q_S}\int_0^{\alpha^*(C, q_S)} f(\alpha)d\alpha =$$

$$= F(\alpha^*(C, q_S))\frac{\partial g(q_S, \alpha^*(C, q_S))}{\partial q_S}$$

because $\frac{\partial g(q_S, \alpha)}{\partial q_S}$ is increasing in α. Thus, this condition can be simplified to

$$\frac{\partial p(C, q_S)}{\partial q_S} > \frac{\partial g(q_S, \alpha^*(C, q_S))}{\partial q_S}.$$

It is straightforward to verify that such a condition holds only if $g_{q_S}(q_S, \alpha^*(0, q_S)) < \frac{U_q}{U_M}$, using the expression for $\frac{\partial p(C, q_S)}{\partial q_S}$ derived in the proof of Lemma 1.1:

$$\frac{\partial p(C, q_S)}{\partial q_S} = -\frac{g_{q_S}(q_S, \alpha^*(C, q_S))f(\alpha^*)U_\beta - U_q g_\alpha(q_S, \alpha^*(C, q_S))w(\beta^*)}{-f(\alpha^*)U_\beta + U_M g_\alpha(q_S, \alpha^*(C, q_S))w(\beta^*)},$$

which concludes the proof.

Proof of Proposition 1.1. Assume that the fee $C > 0$ is fixed. The optimal quality standards q_S^q are defined by the equation

$$\int_0^{\alpha^*(C, q_S)} \left(\frac{\partial p(C, q_S)}{\partial q_S} - \frac{\partial g(q_S, \alpha)}{\partial q_S}\right) f(\alpha)d\alpha = 0$$

in the case in which the SRO can regulate only quality. If the SRO is able to enforce a minimal profit $C > 0$, then the total profit optimizing standards q_S^n are

$$\int_0^{\alpha^*(C, q_S)} \left(\frac{\partial p(C, q_S)}{\partial q_S} - \frac{\partial g(q_S, \alpha)}{\partial q_S}\right) f(\alpha)d\alpha + \frac{\partial \alpha^*(C, q_S)}{\partial q_S} f(\alpha^*(C, q_S))C = 0.$$

I have already established that

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}}{U_M}$$

in both equilibria and thus

$$\frac{\partial \alpha^*(C, q_S)}{\partial q_S} < 0.$$

Thus,

$$\int_0^{\alpha^*(C, q_S)} \left(\frac{\partial p(C, q_S)}{\partial q_S} - \frac{\partial g(q_S, \alpha)}{\partial q_S}\right) f(\alpha)d\alpha > 0$$

at quality q_S^n. Since the equality holds at q_S^q (regulation of quality only) and the first order conditions are assumed monotonic, it follows that

$$q_S^n < q_S^q.$$

Thus, the ability to control the number of members reduces quality standards.

Proof of Proposition 1.2.   The maximization problem

$$W \;=\; CF(\alpha^*(C,q_S)) + \int_{p^*(C,q_S)}^{\infty} W(\tilde{\beta}(p,q_S))dp \;+$$

$$+ \int_0^{\alpha^*(C,q_S)} (p^*(C,q_S) - C - g(q_S,\alpha))\, f(\alpha)d\alpha$$

has two FOC, one with respect to fee C and the other with respect to standards q_S.

$$[C]: F(\alpha^*(C,q_S)) \;+\; Cf(\alpha^*(C,q_S))\frac{\partial \alpha^*(C,q_S)}{\partial C} - \frac{\partial p^*(C,q_S)}{\partial C}W(\beta^*(C,q_S)) \;+$$

$$+ \; \frac{\partial \alpha^*(C,q_S)}{\partial C}(p^*(C,q_S) - C - g(q_S,\alpha^*(C,q_S)))\, f(\alpha) \;+$$

$$+ \; \int_0^{\alpha^*(C,q_S)} \left(\frac{\partial p(C,q_S)}{\partial C} - 1\right) f(\alpha)d\alpha = 0$$

Since

$$\int_0^{\alpha^*(C,q_S)} \left(\frac{\partial p^*(C,q_S)}{\partial C} - 1\right) f(\alpha)d\alpha \;=\; \left(\frac{\partial p^*(C,q_S)}{\partial C} - 1\right) F(\alpha^*(C,q_S)),$$

$$p^*(C,q_S) - C - g(q_S,\alpha^*(C,q_S)) \;=\; 0$$

$$F(\alpha^*(C,q_S)) \;=\; W(\beta^*(C,q_S)),$$

the first order condition can be rewritten as[27]

$$Cf(\alpha^*(C,q_S))\frac{\partial \alpha^*(C,q_S)}{\partial C} = 0.$$

This implies $C = 0$, because if $C > 0$

$$Cf(\alpha^*(C,q_S))\frac{\partial \alpha^*(C,q_S)}{\partial C} < 0, \text{ because } \frac{\partial \alpha^*(C,q_S)}{\partial C} < 0,$$

which leads back to $C = 0$. The other first order condition is

$$[q_S] \;\; : \;\; Cf(\alpha(q_S,C))\frac{\partial \alpha^*(C,q_S)}{\partial q_S} + \int_0^{\alpha^*(C,q_S)} \frac{\partial p(C,q_S)}{\partial q_S} - \frac{\partial g(q_S,\alpha)}{\partial q_S}d\alpha \;+$$

$$+ \int_{p^*(C,q_S)}^{\infty} w(\tilde{\beta}(p,q_S))\frac{\partial \tilde{\beta}(p,q_S)}{\partial q}dp - \frac{\partial p^*(C,q_S)}{\partial q_S}W(\beta^*(C,q_S)) = 0.$$

Under $C = 0$, this condition becomes

$$[q_S] : -\int_0^{\alpha^*(0,q_S)} \frac{\partial g(q_S,\alpha)}{\partial q_S}d\alpha + \int_{p^*(0,q_S)}^{\infty} w(\tilde{\beta}(p,q_S))\frac{\partial \tilde{\beta}(p,q_S)}{\partial q}dp = 0.$$

This condition is rather intuitive. The standards are set optimally when the change in the production costs due to an increase in standards equals the change in gross consumer surplus.[28]

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[27]Note that the marginal firm has zero profit.

[28]"Gross consumer surplus" means the surplus change when prices are constant. The "net" consumer surplus then denotes the surplus minus the expenditures.

Proof of Proposition 1.3. The SRO chooses the standard such that

$$F(\alpha^*(0, q_S)) \frac{\partial p(0, q_S)}{\partial q_S} = \int_0^{\alpha^*(0, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S} f(\alpha) d\alpha.$$

The welfare optimum is described by

$$\int_{p^*(0, q_S)}^{\infty} w(\tilde{\beta}(p, q_S)) \frac{\partial \tilde{\beta}(p, q_S)}{\partial q} dp = \int_0^{\alpha^*(0, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S} d\alpha.$$

By comparing these two conditions, one can see that the SRO chooses the welfare optimal level of standards if and only if

$$\int_{p^*(0, q_S)}^{\infty} w(\tilde{\beta}(p, q_S)) \frac{\partial \tilde{\beta}(p, q_S)}{\partial q} dp = F(\alpha^*(0, q_S)) \frac{\partial p(0, q_S)}{\partial q_S}.$$

Similar results hold in the case in which fee C is exogenously set to a positive level.

Proof of Proposition 1.4. Let us denote

$$G(q_S) = F(\alpha^*(0, q_S)) \frac{\partial p(0, q_S)}{\partial q_S} - \int_0^{\alpha^*(0, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S} f(\alpha) d\alpha.$$

The welfare optimal choice of standards for fee $C = 0$ is given by the condition

$$\int_0^{\alpha^*(0, q^{WO})} \frac{\partial g(q^{WO}, \alpha)}{\partial q^{WO}} f(\alpha) d\alpha = \int_{p^*(0, q^{WO})}^{\infty} w(\tilde{\beta}(p, q^{WO})) \frac{\partial \tilde{\beta}(p, q_S)}{\partial q_S} \Big|_{q_S = q^{WO}} dp.$$

Thus, if

$$F(\alpha^*(0, q_S)) \frac{\partial p(0, q_S)}{\partial q_S} < \int_{p^*(0, q_S)}^{\infty} w(\tilde{\beta}(p, q_S)) \frac{\partial \tilde{\beta}(p, q_S)}{\partial q} dp$$

at q^{WO}, then also

$$F(\alpha^*(0, q^{WO})) \frac{\partial p(0, q^{WO})}{\partial q_S} < \int_0^{\alpha^*(0, q^{WO})} \frac{\partial g(q^{WO}, \alpha)}{\partial q^{WO}} f(\alpha) d\alpha$$

because, by the definition of q^{WO} (above),

$$\int_0^{\alpha^*(0, q^{WO})} \frac{\partial g(q^{WO}, \alpha)}{\partial q^{WO}} f(\alpha) d\alpha = \int_{p^*(0, q^{WO})}^{\infty} w(\tilde{\beta}(p, q^{WO})) \frac{\partial \tilde{\beta}(p, q_S)}{\partial q_S} \Big|_{q_S = q^{WO}} dp.$$

Thus, $G(q^{WO}) < 0$. If $G(q_S)$ is decreasing, then $q^{SRO} < q^{WO}$ because $G(q^{SRO}) = 0$ by definition. Note that the proof for $C > 0$ would be more complicated because the government takes into account the impact of the standards on revenues from the SRO, while the SRO does not.

Proof of Proposition 1.5. In equilibrium the SRO chooses standards q^{SRO} such that

$$g_{q_S}(q_S, \alpha^*(q_S, C)) > \frac{U_q}{U_M},$$

while the CO chooses standards q^{CO} such that

$$g_{q_S}(q_S, \alpha^*(q_S, C)) = \frac{U_q}{U_M}.$$

If C is fixed, then both left and right hand sides are functions of q_S only. If the function

$$G(q_S) = g_{q_S}(q_S, \alpha^*(q_S, C)) - \frac{U_q}{U_M}$$

is increasing in q_S, then

$$G(q^{CO}) = 0, \ G'(q^{SRO}) > 0 \implies q^{SRO} > q^{CO}.$$

Note that one must consider the total derivative of g_{qs} and $\frac{U_q}{U_M}$ because of the indirect effect that q_S has on prices p^* and participation α^*, β^*.

Proof of Proposition 1.6. For a positive fee, the welfare optimum is defined as

$$[q_S] \quad : \quad Cf(\alpha(q_S, C))\frac{\partial \alpha^*(C, q_S)}{\partial q_S} - \int_0^{\alpha^*(C, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S} d\alpha +$$

$$+ \int_{p^*(C, q_S)}^{\infty} w(\tilde{\beta}(p, q_S))\frac{\partial \tilde{\beta}(p, q_S)}{\partial q} dp = 0.$$

Since

$$\frac{\partial g(q_S, \alpha^*(q_S, C))}{\partial q_S} = \frac{\partial p(q_S, C)}{\partial q_S} = \frac{U_{q_S}}{U_M}$$

and g_{q_S} is increasing in α, it is

$$F(\alpha^*(C, q^{CO}))\frac{\partial p(C, q^{CO})}{\partial q_S} > \int_0^{\alpha^*(C, q^{CO})} \frac{\partial g(q^{CO}, \alpha)}{\partial q^{CO}} f(\alpha) d\alpha.$$

I evaluate the first order condition of the welfare optimality at q^{CO}. Since $\frac{\partial \alpha^*}{\partial q_S} = 0$, it follows that

$$-\int_0^{\alpha^*(C, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S} d\alpha + \int_{p^*(C, q_S)}^{\infty} w(\tilde{\beta}(p, q_S))\frac{\partial \tilde{\beta}(p, q_S)}{\partial q} dp = 0,$$

which is positive because

$$\int_0^{\alpha^*(C, q_S)} \frac{\partial g(q_S, \alpha)}{\partial q_S} f(\alpha) d\alpha \quad < \quad F(\alpha^*(C, q^{CO}))\frac{\partial p(C, q^{CO})}{\partial q_S}$$

$$< \quad \int_{p^*(C, q_S)}^{\infty} w(\tilde{\beta}(p, q^{CO}))\frac{\partial \tilde{\beta}(p, q^{CO})}{\partial q} dp.$$

Using the monotonicity of welfare, one can conclude that the value of q^{CO} is smaller than welfare optimal q^{WO}.

Example 1.1 (and proof of Proposition 1.7) *In equilibrium, standards chosen by a self-regulatory organization at fee $C = 0$ may be higher or lower than those chosen by a certifying organization at C^*, depending on the parametrization. I will provide two examples of parametrization that lead to opposite outcomes. First, I show that it may happen that the SRO chooses lower quality than the CO.*

Assuming the following parametrization: $g(q, \alpha) = q^2 + q\alpha + \alpha$, $f(\alpha) = w(\beta) = 1$, $U(\beta, q, M) = (1 - \beta)q + M - p$, one can easily show that the optimal standard for the SRO is $q^{SRO} = 0.41$ for zero fee $C = 0$. The CO chooses standards $q^{CO} = 0.43$ and charges a fee for certification $C = 0.123$.

The second example uses the following parametrization: $g(q, \alpha) = q^3 \alpha$, $f(\alpha) = w(\beta) = 1$, $U(\beta, q, M) = (1 - \beta)q + M - p$. In such a situation, the SRO chooses standard $q^{SRO} = \sqrt{3}$. The CO chooses standard $q_S^{CO} = 1$, which is lower than the standard chosen by the SRO.

Proof of Proposition 1.8. First order conditions are

$$[C] \quad : \quad f\left(\alpha^*(C, q_S)\right) \frac{\partial \alpha^*(C, q_S)}{\partial C} p(C, q_S) + F\left(\alpha^*(C, q_S)\right) \frac{\partial p(C, q_S)}{\partial C} = 0, \text{ and}$$

$$[q_S] \quad : \quad f\left(\alpha^*(C, q_S)\right) \frac{\partial \alpha^*(C, q_S)}{\partial q_S} p(C, q_S) + F\left(\alpha^*(C, q_S)\right) \frac{\partial p(C, q_S)}{\partial q_S} = 0.$$

Note that for the second condition to be satisfied, the signs of $\frac{\partial \alpha^*(C, q_S)}{\partial q_S}$ and $\frac{\partial p(C, q_S)}{\partial q_S}$ have to be different, which means

$$\frac{\partial \alpha^*(C, q_S)}{\partial q_S} < 0.$$

This happens only if

$$g_{q_S}(q_S, \alpha^*(C, q_S)) > \frac{U_{q_S}}{U_M}.$$

For the rest of the proof, see the proof of Proposition 1.5 comparing standards chosen by the SRO and CO for a given fee.

Proof of Proposition 1.9. The first order conditions of the maximization problem

$$\max_{q_S, C} F\left(\alpha^*(C, q_S)\right)$$

$$[q_S] \quad : \quad f\left(\alpha^*(C, q_S)\right) \frac{\partial \alpha^*(C, q_S)}{\partial q_S} = 0$$

$$[C] \quad : \quad f\left(\alpha^*(C, q_S)\right) \frac{\partial \alpha^*(C, q_S)}{\partial C} = 0,$$

and results from Lemma 1.1 $\frac{\partial \alpha^*(C, q_S)}{\partial C} < 0$ show that to maximize the number of certified producers, it is optimal to choose $C = 0$. Moreover, since standards are determined by the condition

$$\frac{\partial \alpha^*(C, q_S)}{\partial q_S} = 0,$$

it is easy to show that the optimal standards are lower than those chosen by the SRO if and only if

$$\frac{\mathrm{d} g_{q_S}(q_S, \alpha^*(q_S, C))}{\mathrm{d} q_S} > \frac{\mathrm{d} \frac{U_{q_S}}{U_M}}{\mathrm{d} q_S}.$$

For the detailed proof, see Proposition 1.5, a comparison of standards chosen by the SRO and CO.

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Chapter 2

Fair Trade—Is It Really Fair?

Joint work with Tomáš Konečný

Abstract:

One of the arguments against the Fair Trade scheme is that the guaranteed minimum price tends to depress world prices and thus the incomes of non-participating farmers (e.g. *The Economist*, 2006). We develop a model that distinguishes between the impact of the introduction of a Fair Trade market *per se* and the effect of minimum price policies given that a Fair Trade market actually exists. The model suggests that the claims against Fair Trade might not be correct. The introduction of a Fair Trade market reduces information asymmetries between the trading parties and dampens the market power of middlemen. Improved matching and lower margins of the middlemen have the capacity to increase the incomes of both participating and non-participating farmers. The minimum contracting price as part of Fair Trade standards, however, precludes the full realization of the program's potential benefits by reducing farmers' payoffs relative to the free-contracting alternative. The minimum price also paradoxically increases the profits of the middlemen whose local monopsony power the Fair Trade scheme originally aimed to retrench. Furthermore, the total surplus generated by Fair Trade cooperatives declines, which translates into reduced investment resources available for the community. From a policy perspective, measures to reduce excess supply such as relaxed-price setting over a stipulated time period or gradual replacement of participating cooperatives by new applicants could provide superior alternatives.

Keywords: Certification, regulation, price setting, coffee, Fair Trade, monopsony
JEL classification: D18, D21, D43, D45, D71, J51, Q17, Q56

2.1   Introduction

As Fair Trade-certified products gradually move from specialized shops to supermarket shelves, the actual impact and potential of Fair Trade has become an increasingly discussed topic. Academics, journalists and policymakers as well as NGOs and other stakeholders involved in the Fair Trade scheme present their worries and expectations regarding the movement's actual capacity to improve the livelihoods of poor people. Besides the common assertion that Fair Trade certification helps marginalized producers through guaranteed minimum prices and other provisions like access to pre-finance or market information (FLO, 2007), the most vocal concerns of Fair Trade opponents relate to the excess Fair Trade supply, the impact on non-participating producers, and the uncertain nature of Fair Trade demand (*The Economist*, 2006; *Washington Post*, 2005; Weber, 2007).[1] These opinions certainly deserve a more detailed analysis as the potential reach of Fair Trade extends to millions of households living in poverty.

This paper aims to address some of the most frequently expressed concerns relating to the Fair Trade certification scheme, namely the excess of Fair Trade supply due to the guaranteed minimum price, the impact on non-participating producers, and the limited scope of Fair Trade demand. In particular, it aims to answer the following questions: What is the impact of the introduction of Fair Trade markets on farmers' incomes? Does the guaranteed Fair Trade price disadvantage those producers who do not engage in Fair Trade compared with those who do? How do the costs and benefits of the scheme depend on the structure of global markets?

We develop a simple framework incorporating the empirical regularities of the largest and most successful Fair Trade market—coffee. Within this framework we distinguish between the impact of the introduction of a market with Fair Trade-certified products[2] and the effect of minimum price policies given that a Fair Trade market actually exists. Furthermore, we study the link between the two above-mentioned measures and the behavior of middlemen operating in regional coffee markets.

The following section provides a brief exposé of the structural changes on the global coffee market in the 90s and the success of Fair Trade-labelled coffee. Section 3 reviews the organization of the Fair Trade labelling scheme and the major arguments favoring the Fair Trade idea. Section 4 develops a model that addresses some of the benefits and concerns relating to Fair Trade in a simple framework first without monopsonistic middlemen and then with the middlemen that control access to world markets. For ease of exposition, Section 4 also contains the numerical results obtained from explicit supply and demand structures. The final section concludes.

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[1]There are, of course, additional arguments against Fair Trade such as the inefficiencies in processing and distribution due to Fair Trade's bypassing of specialized intermediaries exploiting economies of scale. Fair Trade has also been criticised as yet another instrument for price discrimination across customers. For the sake of clarity, our paper does not address these issues and instead focuses exclusively on the excess supply argument and the corresponding impact on farmers.

[2]The assumption that there indeed exists a demand for such products can be justified by Andreoni (1990)'s "warm glow" effect. In the present context, the "warm glow" effect reflects the additional utility due to the consumption of coffee grown under "fair" standards.

2.2 Fair Trade and the global coffee market

The Fair Trade idea is usually associated with coffee, the most successful Fair Trade commodity with the largest share in total sales and the longest history among traded Fair Trade commodities.[3] The growth of Fair Trade can be neatly illustrated by the story of this commodity. The yearly average increase in total sales volume of Fair Trade coffee over the period 2001-2006 amounted to 27%, with growth rates increasing on a yearly basis and reaching as much as 53% in 2006 (FLO, 2007). The extraordinary growth can be attributed mostly to the expanding market in the United States, where only in 2006 sales volume more than doubled. Nonetheless, in Europe with its 79,000 sales points, the market share of Fair Trade coffee has been likewise increasing substantially. In the United Kingdom, the market share of ground Fair Trade coffee increased from 1.5% in 1999 to 20% in 2004 (FINE, 2005).[4] While in other European countries the growth rates and market shares have been more modest, they still exceed the annual growth of world coffee demand (0.4%) by an order of magnitude. Hence, despite a still negligible share in the overall world coffee consumption (0.8% out of a total 6.7 million tons in 2006; FLO, 2007 and ICO, 2007),[5] the continuing expansion of specialty markets and rising consumer awareness of the Fair Trade concept[6] call for a closer evaluation of the respective pros and cons. We begin with developments on the world coffee markets over the last few decades.

2.2.1 Coffee crisis in the 90s

Until 1989, the global coffee market was regulated through the International Coffee Agreement (ICA), a set of agreements that stipulated production quotas and governed quality standards for the majority of produced coffee. The disintegration of the ICA and the following sharp rise in coffee supply coincided with stagnating demand and the market concentration of major roasting and trading companies. On the supply side, the quota abolition led to the output expansion of existing producers (e.g., Brazil), as well as the entry of new significant players (Vietnam) specializing in the production of lower quality Robusta coffee. The demand side, on the other hand, witnessed improved processing technologies that removed the bitter taste of cheaper coffee beans such as Robusta and "natural" Arabica. These advances shifted roasters' demand away from traditional coffee exporters from Central America specializing in a more expensive mild Arabica (Lindsey, 2003).[7] The coffee glut has been further exacerbated by the long adjustment lags typical for coffee production.[8]

Except for short periods of recovery in the mid-90s, coffee prices reached historical lows

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[3]In North America, coffee accounted for 34% of all Fair Trade sales in 2003 (EFTA, 1998). According to the European Commission (1999), the estimated share of Fair Trade food products totaled 60% of the overall Fair Trade retail turnover within the EU. Coffee made up approximately 50% of the above-mentioned share.

[4]Note that the figures refer to ground coffee, for instant coffee the shares are much lower (FLO, 2007).

[5]According to the FLO (2007), the worldwide certified sales of all Fair Trade products amounted to roughly 2.3bln USD. The overall sum would be slightly higher given that the figure does not include non-certified Fair Trade articles. Given this minor share, one could argue that the cross-price effects impacting the non-participating farmers are likely to be rather tame, if any. In Section 4 we argue that this might not be the case.

[6]Moore (2004) cites survey evidence on the expanding share of FT consumers describing themselves as "ethical", or "strongly ethical".

[7]According to Wasserman (2002), cited in Lindsey (2003), the estimated percentage of mild Arabica in the roasters' leading coffee blends dropped from 50% in 1989 to 35% in 2001.

[8]It takes several years before beans can be first harvested.

and led to substantial hardship in the affected rural economies.[9] In October 2001, the price of higher quality Arabica coffee[10] quoted at the New York Board of Trade reached its lowest level in 30 years at 45 cents/lb. For the sake of comparison, Bacon (2005) puts the estimated average monetary production costs of small farm producers to vary between 49 and 79 cents/lb. Nonetheless, since 2001 the price of Arabica coffee has gradually risen so that in October 2007 it has surpassed the Fair Trade minimum price 121 cents/lb.

2.2.2   Growth of specialty markets

While demand for normal "bulk" coffee has been stagnating and its prices have been falling, the specialty coffee sector has been growing fast. For example, the U.S. gourmet coffee market in 2001 represented 40% of the total market value and 17% by volume with annual growth rates well above 5% (Giovanucci, 2001). The continuing success of specialty brands has reflected increasing consumer demand for high quality, taste and an attractive "story" behind each cup of coffee. The Fair Trade and organic labels were able to keep up with these market differentiation trends and although they represent still a relatively minor share in the specialty coffee sector (3-5% in the U.S. specialty coffee retail market (Giovanucci, 2001)), their position becomes stronger each year. Apart from increasing market shares in the gourmet sector, the growing importance of Fair Trade in the coffee market becomes apparent from both its increasing recognition by customers and widening presence in common distribution channels. The former can be illustrated by survey evidence according to which 74% of the French population understood the notion of Fair Trade and 50% of the adult population in the UK recognized the Fair Trade label (FINE, 2005). Fair Trade products have also become increasingly available in "mainstream" retail outlets. In Europe only, the number of supermarkets with a Fair Trade selection increased from 43,100 in 1999 to 56,700 in 2004 (FINE, 2005), i.e., by 32%. The origins, organization and working of Fair Trade networks facilitating the above-mentioned market progress is described in more detail in the following section.

2.3   The origins, organization and benefits of Fair Trade

The Fair Trade movement can be traced back more than 40 years when Alternative Trade Organizations (ATO) established trade networks connecting marginalized producers in developing countries with socially aware customers in developed markets. In 1997 several independent labelling initiatives formed Fairtrade Labelling Organization International (FLO). Five years later FLO launched the FairTrade label in order to harmonize different labels used at the time.

The organization currently works with 569 Fair Trade-certified producer organizations representing over 1.4 million farmers and workers in 57 countries in Africa, Asia and Latin America (FLO, 2007). Similar to other Fair Trade initiatives, the FLO supports Fair Trade

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[9]Bacon (2005) mentions substantial rural-urban migration in Matagalpa, Nicaragua and eroded farmlands following the substitution from coffee to cattle pasture in Coto Brus, Costa Rica. Similar observations from other regions can be found in e.g. Raynolds (2002a) or Ronchi (2002).

[10]Arabica and Robusta are the two main coffee species produced. While Arabica is grown mostly in Latin America and Eastern Africa, major producers of Robusta coffee are located in Brazil, Uganda, India and South-East Asian countries (ICO, 2007).

through the linking of producers with traders in order to match supply and demand, liaison with producer organizations to strengthen their production and export capacities, and lobbying at international forums on trade and development. Nonetheless, the main task of the FLO is the standard setting, certification and monitoring of the Fair Trade Certification Trademark recipients.

2.3.1 Fair Trade and labelling

Of course, coffee is not the only Fair Trade article and not all Fair Trade products are certified. According to FLO data, the retail value of all Fair Trade products sold in 14 European countries in 2005 totaled €657m at minimum, out of which €597m (i.e., approximately 90%) came from the sales of certified products. The labelling scheme covers almost exclusively food products. Besides coffee as a leading and most successful commodity, the Fair Trade certification portfolio covers a number of other major crops including bananas, cocoa and rice. The certification standards vary by commodity and production process (small-scale farming vs. production by hired labor) and distinguish between producers and traders.

In the case of coffee, traders have to trade directly with Fair Trade producers and:

1. pay at least a guaranteed minimum price (121 cents/lb for Arabica coffee) or above to cover the costs of sustainable production. In case the coffee price quoted at the New York Board of Trade exceeds the Fair Trade Minimum Price, the Fair Trade price equals the New York price,

2. pay the Fair Trade premium 10 cents that should be used by producers for community development or investment by individual producers,

3. offer pre-financing/liquidity up to 60% of the contract value,

4. sign contracts that promote long-term sustainable planning.

Fair Trade coffee producers, on the other hand, have to

1. be small-scale farmers associated in a democratic organization,

2. have the necessary export capacity,

3. pursue environmentally friendly production techniques (FLO, 2007).

The most visible Fair Trade benefit to the participating farmers seems to be the Fair Trade Minimum Price. Shocks and long adjustment lags of inelastic supply and demand in the global coffee market directly translate into price fluctuations, which can inflict significant hardship on micro- and small-scale producers accounting for a significant part of the overall coffee production structure (see e.g., Raynolds (2002a) or Moore (2004)).[11] These producers face limited opportunities to cope with adverse market developments especially in periods of prolonged low prices.

However, the availability of the minimum Fair Trade price during times of coffee gluts and low market prices might result in excess supply that forces FT farmers to sell part of

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[11]In Central America, approximately 85% or 250,000 farms are micro- and small-scale (CEPAL, 2002 cited in Bacon, 2005).

their production via traditional channels. Depending on the relative prices and costs of their production on FT and regular markets, it is possible that the excess supply regime brings losses to some of the farmers. In Section 4, we develop a model that allows us to study these effects.

2.3.2   Other benefits of Fair Trade

The minimum Fair Trade price is not the only benefit to the participating farmers. The interviewed farmers often mention the advantages of stability rather than the actual level of the price.

An even more important dimension of Fair Trade, however, seems to be the access to developed markets as well as the expert assistance from Fair Trade organizations aimed to improve farmers' position on the market. Fair Trade cooperatives often perceive the scheme as an opportunity to learn about current demand trends and quality expectations by customers. Relationships between the cooperatives and ATOs usually exceed the notion of a common market transaction and can include joint investments or the development of marketing strategies for the developed market. Raynolds (2002b, p. 419) claims that

> in many cases the technical expertise and market information provided through Fair Trade may be more important for producer associations than the financial and commodity arrangements... This information is critical for those selling their coffee via conventional channels or seeking organic specification.

In addition, many producers (Raynolds (2002a), FLO (2007)) stated the elimination of middlemen and farmers' direct Fair Trade experience markedly improved their bargaining position vis-à-vis other market agents and official authorities.

2.4   Model

While the farmers' narratives consistently report higher or at least stable incomes and improved living conditions due to the guaranteed Fair Trade price, the question still remains how the very existence of Fair Trade, the minimum price and other dimensions of the scheme impact upon non-participating producers. Fair Trade has been sometimes called a mechanism creating an excess supply of coffee, which ultimately hurts the non-participating farmers through a lower equilibrium price on the global market (*The Economist*, 2006). In this section we argue that regardless of the degree of competition on local coffee markets, the introduction of a Fair Trade market *per se* leads to an improvement or at worst a preservation of all farmers' incomes unless the total realized demand for both types of coffee decreases in a new equilibrium.[12] In this respect, what many critics seem to address is not the actual existence of a market with Fair Trade-certified products but the effect of a guaranteed rather than market-determined Fair Trade price. This, together with Fair Trade's impact on middlemen's behavior and profits, is also a major focus of our study.

In this section we develop a model that allows for several transmission channels that might impinge on both participating and non-participating farmers. The model addresses

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[12]The question how the demand for coffee changes when a FT market is introduced is primarily a question about consumer preferences. Since we could argue for an increase or decrease in demand, we leave this question open.

the following questions: What is the impact of the introduction of Fair Trade markets on farmers' incomes? Does the guaranteed Fair Trade price disadvantage those producers who do not engage in Fair Trade compared with those who do? How do the costs and benefits of the scheme depend on the structure of the markets?

For the sake of simplicity, we divide the exposition into two subsections. The opening subsection assumes the absence of middlemen with monopsonistic positions vis-à-vis the farmers. The basic setup presents a world describing two coexisting, perfectly competitive markets (one for conventional coffee, the other for Fair Trade coffee) supplied by farmers from regions. We first compare the two-market outcomes to the case with a single market for normal coffee and then examine the impact of the Fair Trade price set above its market-clearing level.

In the second part, we extend this framework by assuming market failure in the distribution chain. In this setup, the middlemen control access to consumers, purchase normal coffee from regional farmers and then deliver their product to the global market. Note that while the world without middlemen described in the opening subsection is a useful benchmark, it is not the existing structure of the coffee market. Our analysis thus allows us to compare the impact of the Fair Trade mechanism in markets that do have powerful middlemen with those that don't. It also allows us to predict what would happen if the role of middlemen were somehow eliminated. Would FT continue to operate if middlemen were absent?

2.4.1 Fair Trade in a world without middlemen

We assume there is a measure one of regions producing coffee and three types of economic agents: farmers producing coffee, consumers and the Fair Trade Organization (FTO). The FTO sets up a new market and decides on the contracting price p^F at which the exchange will occur. The FTO does not engage in actual Fair Trade transactions and instead focuses purely on the institutional support of Fair Trade exchange. Assume each farmer decides between investment into the production of 1 unit of coffee or an outside option normalized to zero.[13] Given that the farmer opted for coffee production, she can sell the harvested coffee on the world market with normal coffee and get p, or to the Fair Trade market at price p^F. In each region there is a measure one of farmers with heterogeneous production costs c and compliance costs f.[14] The production costs c follow a general distribution function with c.d.f. $G(c)$ defined over support $\langle 0, 1 \rangle$. All farmers can also enter the Fair Trade market, yet the cost of doing so for each farmer is f. We assume the following timing:[15]

1. The FTO sets up the FT market and sets the price p^F.

2. Farmers choose between no production (outside option), production of regular coffee, and production of certified FT coffee.

3. Production and trading take place.

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[13] The normalization has been adopted for the sake of simplicity. While farmers might well face positive and possibly heterogeneous outside options, these can be absorbed by the production cost parameter c. The parameter would then have to be rescaled and reinterpreted as net investment costs into coffee production.

[14] Given the absence of an intensive production margin, both types of farmers' costs are in principle fixed. We discuss their nature as well as the mutual relationship between c and f later in this section.

[15] We focus on subgame perfect equilibria, in which all players correctly expect those variables that are determined later in the game. For example, farmers correctly expect the price of coffee on the world market, p.

The case for heterogeneity in production cost c is rather straightforward. Farmers' education, experience, family size, equipment and soil fertility generally differ, which translates into corresponding differences in farm cost levels.

The relationship between production costs c and compliance costs f is less clear and derives directly from the nature of certification standards determined by the FLO. We argue that these costs are negatively correlated with farmers' productivity. To start with, the farmers willing to produce and sell under the FLO label have to be organized into cooperatives, keep records of all income and expenses and follow a number of other FLO monitoring guidelines. It seems quite reasonable to assume that the compliance with this kind of costs will be easier for more productive farmers whose lead in productivity presumably links to their superior management skills and expertise. The FLO's standards also include progress requirements in terms of growth or volume, again favoring those with higher productivity. Our emphasis on intangible skills such as know-how and management capacity rather than production technologies in a traditional "narrow" sense likewise conforms to the anecdotal evidence. For example, Raynolds (2002b) mentions the case of a Mexican cooperative that succeeded in Fair Trade largely through its years of experience in conventional markets. Similarly, Weber (2007) reports the difficulties of younger, less experienced producer organizations with entering the Fair Trade markets while Raynolds (2002a) emphasizes the necessary strong leadership and capacity to innovate.

A fraction of compliance costs f can be attributed to the certification fees derived from the FLO's certification scheme. These take the form of a flat yearly fee paid to the FLO to cover the costs of certification and expenses related to on-site inspections. Note that the certification fee applies to the whole cooperative and thus introduces an incentive to expand in order to reduce the per-capita certification cost. Since the incentives at the cooperative level lie outside the primary focus of our paper, we abstract from this issue and assume the per capita certification fee to be fixed so that the positive correlation between production costs c and overall compliance costs f will be preserved.

In addition to the positive correlation between the two types of costs, we assume that the compliance costs are indivisible. That is, farmers cannot choose to incur only a part of the compliance costs f, depending on the proportion of their harvest targeted to the Fair Trade market. Given that the above-mentioned compliance costs relate largely to farm attributes that are indivisible in nature, we believe our assumption to be a reasonable one.

As far as the other assumptions, the introduction of multiple regions reflects the fact that coffee growing areas are typically spatially divided among private middlemen taking a monopsonist or oligopsonist position with respect to local farmers. Arbitrage among regions is in practice limited given the lack of information, poor infrastructure and natural barriers in mountainous areas where many small-scale coffee producers live (see e.g. Ronchi, 2002).[16]

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[16]The normalization of the number of regions to 1 has been used for ease of exposition. Note that this does not impact the results. The interested reader may simply multiply demand functions by $\frac{1}{n}$ (where n stands for the number of regions) and proceed with the analysis. Similarly, one might argue that the distribution of the Fair Trade production across regions is not symmetric. Allowing for a fraction of regions to be without Fair Trade production (yet with the same assumed cost structure) would impact on the relative strength of individual channels at work. The qualitative picture, however, would not change. Finally, one might argue that the cost structure is not identical across regions. In such a case, the model might be given an alternative interpretation, where the overall cost distribution across internally homogeneous regions follows c.d.f. $G(c)$ and a single middleman with sole access to world markets decides on the overall amount of purchases. The assumption of the middleman being a price taker on world markets, however, would be rather difficult to justify.

We also do not allow for production adjustment at the intensive margin and instead assume a fixed output per farmer. As Weber (2007) observes, FLO generally does not induce a higher Fair Trade supply of presently participating farmers and instead re-channels the existing production from conventional markets through the certification of additional applicants. Even if this was not the case, however, the situation of farmers often does not permit a significant expansion of output due to either the absence of key productive assets such as land or capital, or the replacement of the former coffee growing areas by urban development (Ronchi,2002; Winters et al., 2004). This fact has also been acknowledged by the European Fair Trade Association, which stated that "given the parcels of land [the farmers] possess and the lack of working capital and resources, [the expansion of output] is almost out of the question" (EFTA, 1998 cited in Ronchi, 2002). Despite the suggestive evidence on its relatively low relevance for farmers' adjustment, the model can nonetheless allow for the intensive margin. The impact of price changes on the numbers of active farmers would then be partly muted via the accommodation of farm output, yet the middlemen's incentives would remain the same, since the middleman is primarily interested in the available quantity of coffee instead of the number of farmers.

The farmers' constraints

In our model, a farmer has three options. Given her expectations regarding the price of regular coffee p, she can take an outside option of zero value (no production), or invest into producing 1 unit of coffee production. Given her decision to invest, she can sell to the market with normal coffee or pay for the FT standards at an additional cost f and sell on the FT market. The participation constraints are

$$
\begin{aligned}
\text{no production:} \quad & p < c \ \& \ \pi p^F + (1 - \pi) p - c < f \\
\text{sell regular coffee:} \quad & p \geq c \ \& \ \pi \left(p^F - p \right) < f \\
\text{sell FT:} \quad & \pi p^F + (1 - \pi) p - c \geq f \ \& \ \pi \left(p^F - p \right) > f,
\end{aligned}
$$

where $\pi \in [0, 1]$ denotes the share of FT production that a farmer is able to sell on the FT market, or equivalently, a probability of being able to sell all of the production for a risk-neutral farmer. The case of $\pi = 1$ corresponds to the situation with both markets clearing.

Rationing

If $\pi < 1$, the Fair Trade price p^F is set above its market-clearing level. As a result, some rationing of the sales of FT coffee has to take place.

The excess supply with $\pi < 1$ is a fairly justified assumption, both theoretically and empirically. First, it is usual to see excess supply on a market in which the price is artificially increased above its equilibrium value. Empirical studies confirm this expectation. According to Bacon (2005), close to 70% of Fair Trade cooperatives' production goes to conventional coffee markets and this figure is attributed to low demand and high quality requirements. The Costa Rican cooperatives examined by Ronchi (2002) sold a mere 49% of their coffee production as Fair Trade. In 2002, the FLO had to temporarily reject pending applicants due to the discrepancy between supply and demand. In the same year the FLO estimated that the supply of Fair Trade coffee was seven times the total Fair Trade volume actually exported (Weber, 2007). While there are other possible explanations why FT farmers might

sell their coffee through conventional markets (e.g, liquidity problems during the harvest season (Bacon, 2005)), in light of the above-mentioned evidence it seems that excess supply plays an important role. In our model, the assumption of FT sales flowing partially through conventional channels relies fully on the excess supply argument.

We assume a proportional rationing rule, ie. excess supply on the FT market makes the participating farmers sell only part of their production through the Fair Trade channel, the rest being directed back to markets with normal coffee. In the rational expectations equilibrium, the expectations will have to coincide with the realized proportion of the total FT output sold to FT customers.

While proportional rationing seems a natural choice, it is not the only possibility and different rules may affect results significantly. For example, if the rationing is done according to the costs of FT production, only farmers with low costs will find it optimal to apply for an FT certificate. This follows from the rational expectations assumption: farmers with higher costs who would be able to sell part of their production under the proportional rationing rule but nothing under the rule based on the costs of production would prefer not to enter in the first place to save on the fee and additional production costs f. This would imply that there would not be any rationing taking place, since only farmers who expect to be able to sell on the FT market will enter it. The impact of an increase in the FT price would thus depend on the effect it has on the quantity of coffee traded. We assume that this effect is negative, which would mean that if the FTO raises the FT price, it restricts the entry of farmers. This does not need to happen under the rationing rule, because a higher price on the FT market may attract more farmers despite a decrease in the probability of a successful trade, as we show later in the numerical example. Since we do observe significant excess supply on the FT market, we prefer the proportional rationing rule.

We make another assumption that might influence our results. We assume that consumers do not care about the excess supply on the FT market. We are not aware of any evidence that would suggest that consumers are aware of the existence of the excess supply or that they change their behavior according to it. One might imagine that the consumers increase their consumption of FT coffee in case of higher excess supply (due to a potentially more significant "warm glow" effect). It is also possible that they would decrease their consumption, because they feel that the organization of FT the market is wasteful and not beneficial to the farmers. Since we use rather general demand functions, an explicit assumption about the consumers' reaction to excess supply would seem arbitrary. However, it might be a interesting venue for future research.

Production costs

The above-mentioned constraints define the potential combinations of c and f (as well as the corresponding cut-off points) that are consistent with the particular participation choices of the farmers. For simplicity, we will assume $f = kc$, where $k \leq 1$ is a parameter.[17] Figure 2.1

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[17]Our specific assumption of the linear relationship between production costs c and compliance costs f satisfies the assumption of a positive correlation between c and f and greatly simplifies the subsequent analysis. We might further allow for a part of compliance costs to reflect the fixed per-capita certification fee discussed in this section, so that $f = a + kc$, $a > 0$. Nonetheless, the positive constant a does not add much to our story (see the curve $f = kc$ in Figure 2.1, which is in fact a special case of $f = a + kc$ with $a = 0$). Also note that independent of the production costs c and given the coffee prices p and p^F, if $k = 0$ and $f = a$, all active farmers would be willing to participate either exclusively in the Fair Trade or the normal market. The price mechanism would then have to adjust so that ultimately the farmers are indifferent between the two choices.
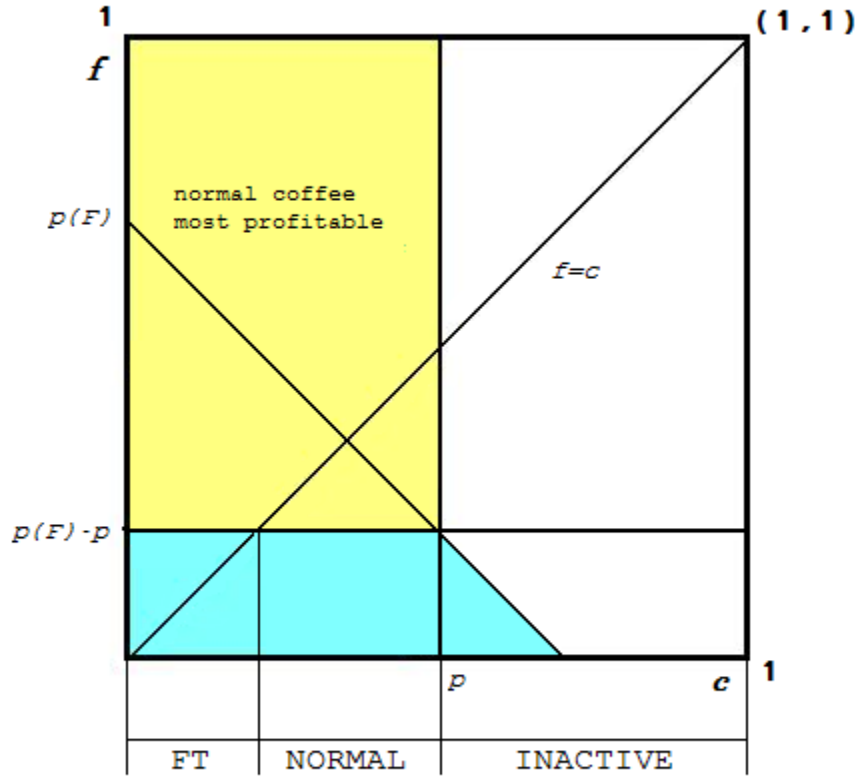
Figure 2.1: Farmers' decisions for various cost combinations (f, c).

illustrates the participation constraints and the respective supplies for normal and FT coffee generated by the line $f = kc$ with $k = 1$ and c distributed uniformly over $\langle 0, 1 \rangle$.

Objective function of the Fair Trade Organization

The Fair Trade Organization is a non-profit institution that claims to aim to improve the living conditions of farmers. It is not clear how this broadly defined motivation translates into a decision about the Fair Trade price and other requirements. Thus, instead of making an explicit assumption about the objective function of the FTO, we study how different choices of the Fair Trade price impacts farmers (both participating and non-participating). This allows us to discuss which objective of the FTO is consistent with its current behavior and which is not.

Hence some heterogeneity in f is needed for the model to become interesting. For the purpose of the testing of our theory, one would need to estimate the value of the parameter k from the costs that FT farmers have in addition to their similar non-FT counterparts. Such an estimation, however, goes beyond the scope of this paper.

Regardless of the objective function of the FTO, its role as a certification body is to guarantee to the consumer that certain conditions (like price, pre-financing, etc.) for the farmers are met. In this respect, the FT certification works like any other certification system. The certifier, FTO, assures consumers about the properties of the good they purchase that they cannot directly or easily observe. Thus, it solves the asymmetry of information problem and facilitates the matching between farmers' supply and consumer preferences. The FTO, however, does not enter into direct transactions with either farmers or traders.

It is easy to find examples of for-profit certification systems but it seems that the for-profit behavior of the FTO would go directly against what it tries to sell. Thus, we focus on possible non-profit objectives instead. It is also important to note that the quality that the certifier provides is not the taste of the coffee and thus Fair Trade complements rather then substitutes vertical differentiation in this respect. Fair Trade certification, even though it requires the sustainability of production processes, does not require that the products are organic. In fact, one can often find both organic and Fair Trade certification of the same coffee.

The equilibrium and comparative statics

We will assume that world demand for FT coffee $D^F\left(p, p^F\right)$ depends on the prices of both types of coffee and satisfies the following restrictions:[18]

$$D^F_p\left(p, p^F\right) > 0, D^F_{p^F}\left(p, p^F\right) < 0 \text{ and } \left|D^F_p\left(p, p^F\right)\right| < \left|D^F_{p^F}\left(p, p^F\right)\right|.$$

A symmetric pattern is required to hold for normal coffee demand $D^N\left(p, p^F\right)$. These assumptions impose reasonable restrictions—the direct price effect is negative and the indirect price effect is positive but smaller in absolute value than the direct effect.

Note that given the minor share of Fair Trade in world coffee consumption (see Section 2), the cross-price effects impacting upon the non-participating farmers could arguably be rather tame (if there are any). In practice, however, even world demand differentiates across regions of origin. As a result, Fair Trade production in e.g. Nicaragua, where the share of Fair Trade production is relatively high, might indeed affect the prices of Nicaraguan coffee. We assume that Fair Trade is strong enough to shift world prices.[19]

We are interested in an equilibrium with both markets being active. If the price p^F becomes market-determined, participation and realized supplies coincide as farmers supply either to the normal or FT coffee market and $\pi = 1$. In the excess supply setup with $\pi < 1$, however, we need to distinguish between the local participation choices and the realized supplies to global markets.

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[18]Several studies such as Broda and Weinstein (2006), Petrin (2002), or Feenstra (1994) addressed the welfare impact of the introduction of new goods/markets within the Dixit and Stiglitz (1977) framework that relies largely on CES utility functions and love-of-variety. In the present context of market creation through environmental or socially conscious labelling, Podhorsky (2006) provides an extension of Melitz (2003)'s industry model with heterogeneous firms where each firm produces a different variety and decides on the adoption of an environmental label. For Fair Trade labelling, however, the goods in question are typically *ex ante* homogeneous (such as locally fragmented coffee production before the introduction of FT) and hence cannot be modelled as a differentiated variety demanded by CES customers. By so doing, it imposes product differentiation among firms/farmers *before* the actual introduction of Fair Trade.

[19]In the Appendix we also provide a model extension in which we assume that the price of FT coffee does not impact the demand for regular coffee.

$$[\text{Participation in FT}]: \quad S^F = G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$$

$$[\text{Participation in N}]: \quad S^N = G(p) - G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$$

$$[\text{Realized FT}]: \quad S^{WF} = \pi S^F$$

$$[\text{Realized N}]: \quad S^{WN} = S^N + (1 - \pi)\, S^F,$$

where N stands for "normal/regular coffee market" and FT for "Fair Trade market". While $G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$ of the total population of farmers choose to participate in the FT scheme, they are not able to sell exclusively to FT markets. Not being able to find enough buyers, their remaining harvest $(1 - \pi)\, S^F$ has to be sold through conventional channels.

In the rational expectations equilibrium, the realized supplies and demands have to be equal.

$$\pi S^F\left(\pi, p, p^F\right) = D^F\left(p, p^F\right) \tag{2.1}$$
$$S^N\left(\pi, p, p^F\right) + (1 - \pi)S^F\left(\pi, p, p^F\right) = D^N\left(p, p^F\right)$$
$$\pi = \pi\left(p^F\right), p = p\left(p^F\right).$$

It is possible to show that there exists an equilibrium under standard conditions, using the Implicit Function Theorem (IFT). The assumptions of the IFT require the existence of a solution in one point, and non-singularity of the Jacobian of the equilibrium conditions. This in fact imposes mild conditions on the supply and demand functions. The existence of an equilibrium is not the prime focus of our paper and we thus do not provide a detailed proof. A numerical example later shows that some equilibria indeed exist. Furthermore, in the Appendix we discuss informally the existence of equilibria in a model with middlemen.

Lemma 2.1 *Under standard conditions on supply and demand functions, there exists an equilibrium for a range of FT prices p^F.*

The following lemma shows that the presence of Fair Trade in our model benefits all farmers under quite general conditions.

Lemma 2.2 *Given that markets clear (i.e., $\pi = 1$), the incomes of all farmers (weakly) increase if and only if the total realized demand does not fall after the introduction of the Fair Trade market.*

Proof. If the overall realized demand in a new Fair Trade equilibrium remains constant, it can exist only if the participating farmers are relatively better off than selling through the conventional channels. The normal farmers' payoffs are furthermore unchanged due to a constant price p.

If the overall realized demand in a new Fair Trade equilibrium increases, the non-participating farmers have to be better off since the actual increase only becomes possible if the previously inactive farmers enter the production and this can only happen once the purchase price of
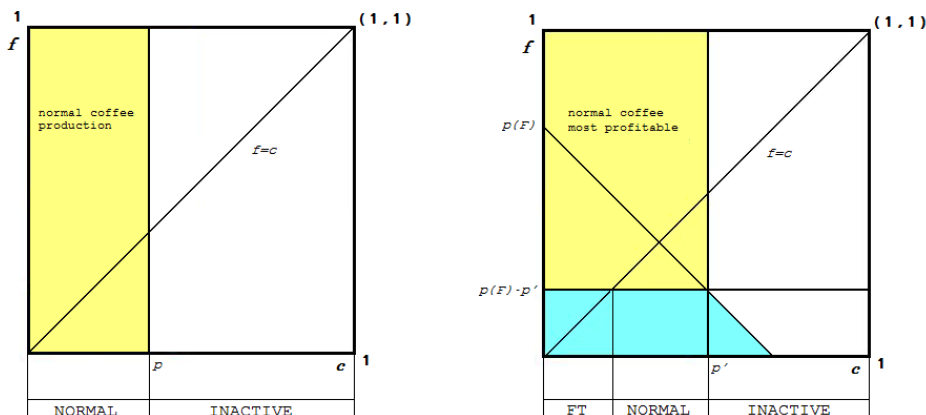
Figure 2.2: Shift away from normal coffee when Fair Trade is introduced (total demand increases)

normal coffee p rises. Furthermore, the participating farmers are unambiguously better off using the same argument as in the case of a small Fair Trade market.

If the total realized demand declines following the introduction of Fair Trade, the fall in the consumption of conventional coffee has been less than compensated by the purchase of Fair Trade coffee. As a result, normal farmers become worse off. Some FT farmers may be better off.

In other words, unless total realized demand does not fall after the introduction of the Fair Trade market, the very introduction of the scheme by the Fair Trade Organization absent any price-setting constraints helps the participating farmers and at least does not hurt the incomes and participation of normal coffee producers. Figure 2.2 illustrates the case where the total realized demand has increased after the introduction of Fair Trade despite a shift away from normal coffee. This happened due to a more-than-compensating rise of Fair Trade consumption.

This result is somewhat similar to third degree price discrimination, where the effect of the discrimination depends on whether it decreases the output.[20] As in the literature on third degree price discrimination, we are also concerned here with the impact of opening a new market. In addition to that, we study how fixing the price on the newly open market affects the previous market. The first question is thus similar to the question in the literature on price discrimination, even though the decision to open the new market is not made by the seller(s) on the old market and each consumer makes purchases on both markets.

Our paper, due to the general structure of the demand side, does not allow us to study in detail the welfare effects of opening a new market with FT coffee and setting an above-equilibrium price on it. For example, if opening the new market reduces the quantity traded on the normal market, the effect on farmers and consumers is heterogeneous. Some farmers (those remaining on regular market) are worse off because of the fall in price; those moving to the FT market may be better off and similarly for consumers. Increasing the price of FT coffee may have positive effects for some FT farmers and farmers on the regular market (due to substitution effects), but may hurt consumers. Unfortunately, a deeper analysis of these effects is impossible without explicitly modelling the demand side.

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[20]We are grateful to Roland Strausz for suggesting this similarity.

Assuming that the equilibrium exists, we are now interested in how it compares with the market-clearing equilibrium at which there is no excess supply on the FT market ($\pi = 1$).

Lemma 2.3 *If there are no middlemen, an increase in price p^F above its market-clearing level increases the excess supply $(1 - \pi)$ and reduces the price of regular coffee p.*

$$\frac{d\pi}{dp^F} < 0, \frac{dp}{dp^F} < 0.$$

All proofs are provided in the Appendix, unless noted otherwise.

Lemma 2.4 *By increasing the price p^F above its market-clearing level, the farmers' participation in the Fair Trade scheme increases if and only if*

$$\left| \varepsilon_{p^F}^{D^N} \frac{S^{WN}}{S^{WF}} \right| < \left| \varepsilon_{p^F}^{\pi} \right| \ \ and \ \ \left| \varepsilon_{p^F}^{D^F} \right| < \left| \varepsilon_{p^F}^{\pi} \right|.$$

The payoffs of farmers participating in Fair Trade decrease unambiguously relative to the market-clearing case.

The intuition behind both lemmas is quite straightforward. Holding other things constant, if the Fair Trade Organization sets the contracting price p^F above its market-clearing level so as to maximize farmers' participation in Fair Trade, the demand for Fair Trade has to fall. Despite the concomitant rise of the demand for conventional coffee (we assume that the indirect price effect is weaker than the direct one), the excess supply of coffee remains preserved and translates into corresponding pressure to reduce the price p. Furthermore, if the demand elasticities are low vis-à-vis excess-supply elasticity $\varepsilon_{p^F}^{\pi}$,[21] the decrease in price p becomes so pronounced that it makes the Fair Trade scheme more attractive and thus increases participation. In such a situation the effects of the minimum price p^F resemble the impact of the minimum wage in labor markets with heterogeneous oligopsonists (Manning (2003)). While the actual mechanism at work varies in each case, both results point to the importance of agent heterogeneity in the modelling of market interventions. This result has a simple corollary.

Corollary 2.1 *In the excess-supply equilibrium with $\pi < 1$, the participation in the Fair Trade scheme can increase relative to the market-clearing case with $\pi = 1$. This might happen despite the fall of the participating farmers' payoffs.*

Increasing the price p^F above its market-clearing level hurts all farmers regardless of their status, since both the price of the regular coffee p and the probability of being able to sell Fair Trade π more than offsets the initial benefit of a higher FT price p^F. The previous result holds even if participation in the Fair Trade scheme actually rises. The FT market becomes relatively more attractive than the regular market, yet the FT payoffs of the switching farmers fall short of the normal-coffee payoffs earned in the market-clearing equilibrium. Had this not been the case, the switching farmers would have acted irrationally in the first place by having chosen normal coffee production in the market-clearing equilibrium.

Nonetheless, given the positive impact of the introduction of the Fair Trade market and monotonically decreasing farmers' payoffs, the FT farmers are still better off as compared to

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[21]The excess-supply elasticity $\varepsilon_{p^F}^{\pi}$ is defined as $\frac{p^F}{\pi} \frac{d\pi}{dp^F}$.

the setup with the non-existent Fair Trade market. To see this, note that if the Fair Trade price p^F were gradually raised up to the level prohibiting the existence of the Fair Trade market, all farmers would supply to the normal market, thus imitating the equilibrium with a single existing market for normal coffee.

In the following, we move away from the analysis of farmers' individual payoffs and instead explore the impact of the excess-supply price p^F both on the aggregated profits of all farmers and on Fair Trade participants only. The aggregated profits serve as a proxy for resources available for community investment.[22]

Lemma 2.5 *In the excess-supply equilibrium with $\pi < 1$, the aggregated profits of all farmers are decreasing.*

The fact that the total profit of all farmers is decreasing in p^F does not tell us whether it is because the profits of both Fair Trade and regular farmers decrease, or because one group benefits in the aggregate while the other does not. The following lemma partially answers this question. It formalizes the intuition that Fair Trade farmers cannot benefit in aggregate if their participation decreases as a result of an increase in price p^F. Note that the lemma actually strengthens this result by showing that even an increase in participation may not be sufficient to guarantee an increase in their profits.

Lemma 2.6 *If the participation of Fair Trade farmers decreases as a result of an increase in p^F, then the overall Fair Trade farmers' profit decreases.*

The observation is straightforward, since we already know that an increase in p^F above its market-clearing level lowers the profits of Fair Trade farmers.[23] The only theoretical possibility thus remains the case when the participation in Fair Trade increases. However, such a condition is not sufficient given the simultaneous fall of Fair Trade farmers' individual profits (see the Appendix). We will return to the possibility of increased overall Fair Trade profits (driven by participation) in the following section with middlemen.

Summary of the results in the world without middlemen

In this section we focused on the effect of the introduction of a Fair Trade market and a binding minimum price p^F in a setup without the presence of monopsonistic middlemen. Our interim results assign a generally positive role to Fair Trade in that setting up a new market might improve the matching of consumers' preferences with farmers' supply. On the other hand, the results conform to the critiques expressed e.g. in *The Economist* (2006) or the *Washington Post* (2005), claiming that the excess supply caused by the binding minimum price policy of the FLO tends to depress the incomes of the non-participating farmers. This

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[22]The literature on Fair Trade lists a number of benefits of Fair Trade that the present framework addresses only indirectly or not at all (for a brief outline and references see the Appendix). One of the frequently mentioned improvements concerns the pooling of resources for the production of positive externalities. Ronchi (2002) reports the efforts of the Costa Rican cooperative COOPELDOS aimed at the maintenance of local roads, other cooperatives provide a number of services such as extended credit or reforestation support also to non-members. Strong rural linkages operating through large expenditure shares of local non-tradeables (e.g., perishable and/or locally processed foods and services) have been emphasized in a study by Winters et al. (2004).

[23]In the absence of quantity adjustment at the farmer's individual level, payoffs and profits can be used interchangeably.

happens through the decline in the normal coffee price p, which in addition forces some of the most disadvantaged to leave coffee production and seek outside options. In this respect the Fair Trade scheme does not help farmers as much as it potentially could, which also translates into profits at the aggregate level. Nonetheless, we assert that once the new Fair Trade market *per se* boosts the farmers' incomes, the excess-supply regime still outperforms the initial situation with a single market for normal coffee.

In the following section we allow for a specific kind of market failure on the normal coffee market and incorporate monopsonistic middlemen, restricting the access to world markets. We will focus on the relationship between Fair Trade, farmers' and middlemen's incomes and the behavior of the normal coffee price p.

2.4.2 Fair Trade in a world with middlemen

Previous sections have dealt with two interconnected markets absent any intermediaries. The middlemen, however, play a significant role in the overall distribution chain and their allegedly exploitative position in fact stood at the very roots of the whole Fair Trade movement (see previous sections). For these reasons we extend the model to allow for the presence of intermediaries. These middlemen purchase coffee from local farmers and they have sole access to world markets.

1. FTO sets price p^F.

2. Middlemen set price p^M.

3. Farmers choose between no production, regular coffee production and FT coffee production.

4. Production and trade take place.

We assume that such a middleman is small with respect to global markets, yet she holds some monopsony power vis-à-vis the farmers.[24] Farmers' choices are identical to those from the previous market-clearing case, yet now instead of the global market price p they receive a price p^M offered by the middleman. We assume farmers have expectations about the probability π of being able to sell their production on the FT market. The case $\pi = 1$ corresponds to no excess supply, while if $\pi < 1$ there is excess supply.

The middleman's problem

Each middleman maximizes her profit so that

$$\max_{p^M} \ (p - p^M) \left[S^N + (1 - \pi) S^F \right]$$

$$\text{s.t. } S^N = G(p^M) - G\left(\frac{\pi \left(p^F - p^M \right)}{k} \right)$$

$$S^F = G\left(\frac{\pi \left(p^F - p^M \right)}{k} \right),$$

---

[24]Our timing also requires that the middlemen can commit to a given price and to buy any amount of coffee from farmers at that price. The second restriction is not binding because in a rational expectations equilibrium, middlemen correctly expect the amount of coffee supplied by the farmers.

which for a given π leads[25] to an implicit solution for p^M.

$$[p^M] : -[S^N + (1 - \pi) S^F] + (p - p^M) \left(g(p^M) + \frac{\pi^2}{k} g \left(\frac{\pi \left(p^F - p^M \right)}{k} \right) \right) = 0 \qquad (2.2)$$

or alternatively,

$$(p - p^M) \left(g(p^M) + \frac{\pi^2}{k} g \left(\frac{\pi \left(p^F - p^M \right)}{k} \right) \right) = G(p^M) - \pi G \left(\frac{\pi \left(p^F - p^M \right)}{k} \right). \qquad (2.3)$$

One can immediately observe that the middleman's optimal price p^M is a function of the success rate of Fair Trade farmers π, the price of the Fair Trade coffee p^F, and the price p the middleman receives on the world market with conventional coffee. The following lemma summarizes the relationship between the purchase price p^M and the above-mentioned variables.

Lemma 2.7 *The middleman's optimal price p^M is an increasing function of all its arguments, i.e., $\frac{\partial p^M}{\partial \pi} > 0, \frac{\partial p^M}{\partial p^F} > 0$, and $\frac{\partial p^M}{\partial p} > 0$.*

Proof.   We provide an intuition for this statement; the formal proof is standard. An increase in the success rate π or the Fair Trade price p^F might make the middleman lose part of the available farmers' supply. In response to this, the middleman partly compensates farmers by raising her purchase price p^M. Similarly, a higher selling price p boosts the middleman's revenues and allows further adjustment on the cost side.

More formally, the middleman sets the optimal price p^M so as to equate the two expressions. If π, p^F, or p increases, the marginal revenue loss for a given p^M increases, while the marginal cost savings fall or remain unchanged. Since the marginal gains in revenues from additional normal coffee purchases exceed the corresponding marginal costs if p^M is relaxed, it is optimal[26] for the middleman to raise the purchase price to $p^{M\prime}$ in order to compensate for the improved outside options of the farmers (upward shifts in π and/or p^F) or to exploit favorable conditions on world markets (higher p).

One can also note that the middleman's optimal price setting means that any market developments reflected in price p translate only indirectly and typically in a less pronounced way into farmers' revenues.[27]

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[25] Even though we normalize the number of regions ($n = 1$) and thus also the number of middlemen for technical simplicity, the model is based on the assumption of a large number of regions. For example, each middleman does not take into account his impact on π, because the excess supply on the FT market depends on the behavior of other middlemen. If there was only one middleman, he would be able to take π as dependent on his price p^M, significantly complicating the model.

[26] The second order condition implies that the slope of the marginal cost-savings function is steeper than the slope of the marginal revenue loss function. As a result, the equality can be restored only at a higher price p^M.

[27] One can conjecture that in most cases $\frac{\partial p^M}{\partial p} < 1$, but the proof depends on the behavior of the derivative of density function g'. Thus, there might exist an equilibrium in which even $\frac{\partial p^M}{\partial p} > 1$. For uniform distribution, one can easily show that $\frac{\partial p^M}{\partial p} = \frac{1}{2}$.

The equilibrium and comparative statics

We start with an analysis of the equilibrium where the FTO decides on a price regime p^F when the middleman is present. If the participating farmers sell only part of their production through the Fair Trade channel, the rest is sold to the middleman.

The farmer's choices change to:

$$
\begin{aligned}
\text{no production:} \quad & p^M < c \ \& \ \left[\pi p^F + (1-\pi)p^M\right] - c < f, \\
\text{sell to middleman:} \quad & p^M \geq c \ \& \ \pi\left(p^F - p^M\right) < f, \\
\text{sell FT:} \quad & \left[\pi p^F + (1-\pi)p^M\right] - c \geq f \ \& \ \pi\left(p^F - p^M\right) \geq f,
\end{aligned}
$$

where p^M is the middleman's optimal price, taking into account the part of the Fair Trade production that could not match Fair Trade markets. As before, we restrict our attention to the case $c = kf$. Similar to the previous case when the middleman is not present, one has to distinguish between farmers' local participation choices and the realized supplies.

We have

$$
[\text{Participation in FT}]: \quad S^F = G\left(\frac{\pi\left(p^F - p^M\right)}{k}\right), \tag{2.4}
$$

$$
[\text{Participation in N}]: \quad S^N = G(p^M) - G\left(\frac{\pi\left(p^F - p^M\right)}{k}\right),
$$

$$
[\text{Realized FT}]: \quad S^{WF} = \pi S^F,
$$

$$
[\text{Realized N}]: \quad S^{WN} = S^N + (1-\pi)\, S^F.
$$

In a rational expectations equilibrium the realized supplies and the realized demands are equal.

$$
S^{WF} = \pi S^F\left(\pi, p^M, p^F\right) = D^F\left(p, p^F\right)
$$
$$
S^{WN} = S^N\left(\pi, p^M, p^F\right) + (1-\pi)S^F\left(\pi, p^M, p^F\right) = D^N\left(p, p^F\right)
$$
$$
\pi = \pi\left(p^F\right), p = p\left(p^F\right), p^M = p^M\left(\pi, p, p^F\right).
$$

Lemma 2.8 *Given that markets clear (i.e., $\pi = 1$), all farmers are better off if and only if the price p^M offered by the middleman increases once the FT market opens. This happens either if the downward adjustment of the world normal coffee price p stays relatively modest, or if the price p actually increases in response to the new FT market.*

The statement of the preceding lemma conforms to our results from Lemma 2.2 that dealt with the world without middlemen. In fact, the present results are slightly stronger than those from Lemma 2.2. The reason is that contrary to the case without middlemen, the non-participating farmers now fare strictly better even if the price of normal coffee remains unchanged. This happens as a consequence of the strategic behavior of the middleman, who finds it profitable to adjust her price p^M slightly so as to mute the outflow of farmers towards Fair Trade. A direct consequence of the middleman's behavior is also that the non-participating farmers can be better off even if the normal coffee price p falls, given that the

effect of a decline in price p does not outweigh the positive effect of Fair Trade farmers'
improved access to world markets.

Moving to the comparative statics, we are now interested in how the price of normal coffee
p changes once the FTO sets price p^F above its market-clearing level (i.e., $\pi < 1$).

Lemma 2.9 *Assume that $\frac{\partial p^M}{\partial \pi} > 0$ is small enough. In the presence of middlemen, an
increase in price p^F above its market-clearing level increases the excess supply $(1 - \pi)$ and
might reduce or increase the price of regular coffee p.*

Increasing p^F above the market-clearing level might lead to four possible responses of p
and π,

$$\frac{dp}{dp^F} < 0, \text{ and } \frac{d\pi}{dp^F} < 0; \frac{dp}{dp^F} > 0, \text{ and } \frac{d\pi}{dp^F} > 0,$$

$$\frac{dp}{dp^F} > 0, \text{ and } \frac{d\pi}{dp^F} < 0; \frac{dp}{dp^F} < 0, \text{ and } \frac{d\pi}{dp^F} > 0.$$

The combination

$$\frac{dp}{dp^F} < 0, \text{ and } \frac{d\pi}{dp^F} > 0$$

is not possible. Technically possible, yet very unlikely, is the case

$$\frac{dp}{dp^F} > 0, \text{ and } \frac{d\pi}{dp^F} > 0.$$

First of all, an increase in π following the departure from market clearing is not a viable option
given that $\pi = 1$ and $\pi \in \langle 0, 1 \rangle$. Secondly, while further away from the market-clearing price
p^F such a constellation might still be permissible, this can happen only if one is willing to
accept $\frac{dD^F(p,p^F)}{dp^F} > 0$.[28] We do not find such an adjustment setting plausible and instead
focus on the remaining options. Thus, there are only two interesting cases where an increase
in p^F raises the excess supply:

$$\frac{dp}{dp^F} < 0, \text{ and } \frac{d\pi}{dp^F} < 0,$$

$$\frac{dp}{dp^F} > 0, \text{ and } \frac{d\pi}{dp^F} < 0.$$

Note that the results from the previous lemma differ markedly from the setup with no
middlemen and contradict the statements by *The Economist* (2006) regarding the declining
normal coffee prices in the excess-supply regime. Given that an excess supply of Fair Trade
coffee is indeed able to influence the prices of regular coffee, these can in principle move in *both*
directions. In particular, the arguments relying on the price mechanism operating through
world markets do not take into account the presence of market failure in the distribution chain.
The introduction of the Fair Trade channel mitigates the negative impact of the middlemen
restricting coffee supplies. The Fair Trade excess-supply regime, on the other hand, returns

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[28]The following lemma states that $\frac{dp^M}{dp^F} < 0$, which together with the present possibility that $\frac{d\pi}{dp^F} > 0$ implies
$\frac{dS^F}{dp^F} > 0$. But then the realized Fair Trade demand D^F has to increase even more than Fair Trade supply
S^F in the new equilibrium in order to be consistent with $\frac{d\pi}{dp^F} > 0$.

part of the market power back to the middlemen, reintroduces previous inefficiency and in some cases might even lead to an actual increase in the prices of regular coffee. Within the discussion of the excess-supply's impact on the incomes of farmers, nonetheless, our results conform to *The Economist* (2006)'scritique.

Lemma 2.10 *In the excess-supply equilibrium with $\pi < 1$, the non-participating farmers are unambiguously worse off relative to the situation with the market-clearing Fair Trade scheme ($\pi = 1$). In other words, $\frac{dp^M}{dp^F} < 0$.*

If $\frac{dp}{dp^F} > 0$, the overall demand falls unambiguously given our demand assumptions and hence $\frac{dp^M}{dp^F} < 0$ in order to have a viable equilibrium. If $\frac{dp}{dp^F} < 0$, we show that it still holds that $\frac{dp^M}{dp^F} < 0$, otherwise the monopsonist does not behave optimally.

Consider the situation of an increased price p^F. Given that price p^F rises and holding price p constant, the demand for Fair Trade falls, so the part of production previously sold as Fair Trade needs to be sold via middlemen to normal markets. Given p^M and p and regardless of farmers' participation choices, the middlemen now face a higher supply from farmers and can adjust optimally. Increasing p^M given p would decrease their profits even if one ignores the unexpected windfall coming from FT. The reason is that in such a case the middlemen would not have been optimizing *ex ante* in the first place. Taking into account the windfall would make their decision even more unprofitable at the margin. So the middlemen will adjust by decreasing the purchase price p^M.

Similarly to the setup without middlemen, we explore the impact of the excess-supply price p^F both on the aggregated profits of all farmers and on Fair Trade participants only.

Lemma 2.11 *If $\pi < 1$, $\frac{d\pi}{dp^F} < 0$, and $\frac{dp^M}{dp^F} < 0$ in an equilibrium, then the revenue of all farmers is decreasing in p^F above its equilibrium value.*

Proof. The proof is identical to the proof of Lemma 2.6, if one substitutes p^M in place of p. The difference between these cases comes from the difference between prices p and p^M. In the case of a market with middlemen, price p is not directly relevant for the decision making of a farmer, because he cannot trade at this price. Even though it might seem unlikely to observe $\frac{dp^M}{dp^F} < 0$ in the case with middlemen or $\frac{dp}{dp^F} < 0$ without middlemen, our numerical example (see Figures 2.3–2.5) show that both cases are possible in general and the first is in fact prevalent. Intuitively, such an outcome happens because the probability of successful trade π decreases enough to offset any favorable increase in price.

Lemma 2.12 *If the participation of FT farmers decreases as p^F increases, then the aggregate FT farmers' profits decrease.*

Proof. Again, use p^M instead of p to obtain the proof.

The preceding lemmas show that it is very unlikely that the aggregate profits of any group of farmers would increase as a consequence of the excess supply Fair Trade regime. Again, the only theoretical possibility remains an increase in the aggregate Fair Trade profits. However, our numerical results produce falling aggregate profits regardless of the participation patterns.[29]

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[29] The same holds for the simulation results in the setup without middlemen.

The present setup with monopsonistic middlemen helped us understand the effects of the introduction of a new Fair Trade market and the negative impact of a minimum binding price on both the normal farmers' incomes and the aggregate profits. Nonetheless, we would also like to analyze the relationship between the excess supply, the participation patterns of both types of farmers, the income of Fair Trade farmers and profits of the middlemen. Since the comparative statics with general demands and supply distributions proves to be excessively complex, in the next subsection we illustrate a number of model outcomes on an example with explicit functional forms.

Example with explicit demands

In this subsection, we analyze the links between participation, incomes, middlemen's profits and the excess supply on a specific example with quasilinear demand preferences and uniform productivity distribution. We specify demand functions using a model of consumers that considers normal and Fair Trade coffee to be imperfect substitutes. Let's assume a quasilinear utility function

$$\tilde{U} = U(x^N, x^{FT}) + Q$$

$$U(x^N, x^F) = \alpha \left(x^N + x^F \right) - \frac{1}{2} \left(\left(x^N \right)^2 + 2\gamma x^N x^F + \left(x^F \right)^2 \right)$$

$$\gamma \in \langle 0, 1 \rangle, \ \alpha, \ \delta > 0,$$

where x^N and x^F are consumptions of normal and FT, Q is the numeraire good. Note that while Richardson and Stähler (2007) treat FT and normal products as perfect substitutes, we take an alternative approach and model the Fair Trade good as an imperfect substitute for normal coffee. In our framework, the degree of substitutability γ is assumed to depend negatively on the "warm glow" effect discussed by Andreoni (1990), which in the present context reflects the additional utility due to the consumption of coffee grown under "fair" standards. Note that higher γ implies a "lower warm glow effect", i.e., regular and FT coffee are easier to substitute.

Consumers maximize their utility given the budget constraint

$$p x^N + p^F x^F + Q \leq M.$$

The maximization problem leads to the demand function for normal and FT coffee, respectively:

$$x^N = \frac{\alpha}{1 + \gamma} + \frac{\gamma}{1 - \gamma^2} p^F - \frac{1}{1 - \gamma^2} p,$$

$$x^F = \frac{\alpha}{1 + \gamma} + \frac{\gamma}{1 - \gamma^2} p - \frac{1}{1 - \gamma^2} p^F.$$

Numerical results

In the following we plot three groups of graphs with our numerical results, each group capturing a specific model dimension. For all graphs, the x-axis represents the excess of the Fair Trade price p^F above its market equilibrium value. The results have been derived for three different values of the substitution parameter γ, namely 0 (dot), 0.5 (circle) and 0.99 (x).

The first group depicts the behavior of equilibrium prices p and p^M and the proportion of production going to Fair Trade π. The graphs show that the proportion of production sold

on Fair Trade markets π decreases with the excess p^F, but this effect is smaller if γ is lower, i.e., when the two types of coffee are harder to substitute. In particular, lower γ leads to a relatively milder drop in the Fair Trade demand, hence the equilibrating adjustment of π does not have to be as pronounced.

Consistent with Lemma 2.10, the graphs also show that the equilibrium price p on the market for normal coffee can be both increasing and decreasing with p^F, depending again on the degree of substitutability. If both types of coffee are easier to substitute (higher γ), then the increase in price p^F leads to a likewise increase in the price of normal coffee p.

The reason for the co-movement of prices p^F and p is the congruent working of the demand for normal coffee and the middleman's incentives to cut costs.[30] Holding farmers' expectations regarding π and p constant, the initial rise in the Fair Trade price p^F reduces the Fair Trade demand. The released Fair Trade output has to be rechanneled back to the middleman. With a higher degree of substitutability γ, this output volume becomes larger, the middleman has a stronger incentive to lower the purchase price p^M, and more of the least productive farmers are thus pushed out of the normal coffee market. At the same time, the cross-price reaction of the demand for normal coffee rises with γ and further dampens the extent of the potential coffee glut. As a result, for a sufficiently strong combination of the middleman's price cutting and demand cross-price effects the overall outcome might be a higher normal coffee price p. Our numerical results in Figure 2.3 conform to the theoretical possibility of a rising price p in the excess-supply regime.

We have already discussed the middlemen's motivation to reduce the purchase price p^M in the excess-supply equilibrium (see Lemma 2.11). The last graph illustrates how the excess supply of Fair Trade coffee strengthens the position of the middlemen relative to Fair Trade with market clearing.[31] As the middlemen's profit margin increases with γ, one might even observe a decline in the living standards of normal farmers and the least effective farmers leaving the market, despite a simultaneous increase in the world price of normal coffee p.

The second group of plots shows how profits depend on the excess of p^F above its market equilibrium value. Farmers' aggregate profits are decreasing in the degree of substitutability between normal and Fair Trade coffee. One can also see how the Fair Trade excess supply regime benefits the middlemen and how the increasing level of γ boosts their profits. The closer substitutes both kinds of coffee are, the faster the middlemen's profits rise both at the intensive $(p - p^M)$ and the extensive (S^{WN}) margin.

Finally, we plot graphs that describe farmers' participation choices and realized supplies as functions of the excess-supply price p^F. The farmers' participation choices are described in plots labelled "normal supply" and "FT supply". The reader will notice that the participation

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[30]Remember that such a constellation would not be possible in the world without middlemen, since there is no mechanism that would work against the downward pressure on the prices of conventional coffee.

[31]In our discussion of the model's adjustment mechanism, we assume that the middleman is not able to distinguish between normal and Fair Trade farmers so that she offers the same price p^M to both groups. In other words, the middleman is not able to discriminate between the two types of producers. The middleman's ability to ration depending on the producer type would lead to the optimal response p^M being set to zero for unsold Fair Trade production, which would in turn lower the Fair Trade farmers' expected payoffs as well as their participation in the scheme. The remaining participating farmers would then de facto play an infinite lottery with the probability π of winning $p^F - c - f$ and the probability $1 - \pi$ of making a loss $-(c + f)$. While we did not find any empirical evidence on middlemen's discrimination based on farmers' status, the main reason for our non-rationing assumption is that the lottery setup represents a rather special sub-case of the present model with no significant changes in results.

Of course, by decreasing p^M, the middleman forgoes some farmers on the produce/stay inactive margin, yet this amount depends on γ only indirectly through the middleman's reaction to the released Fair Trade output.
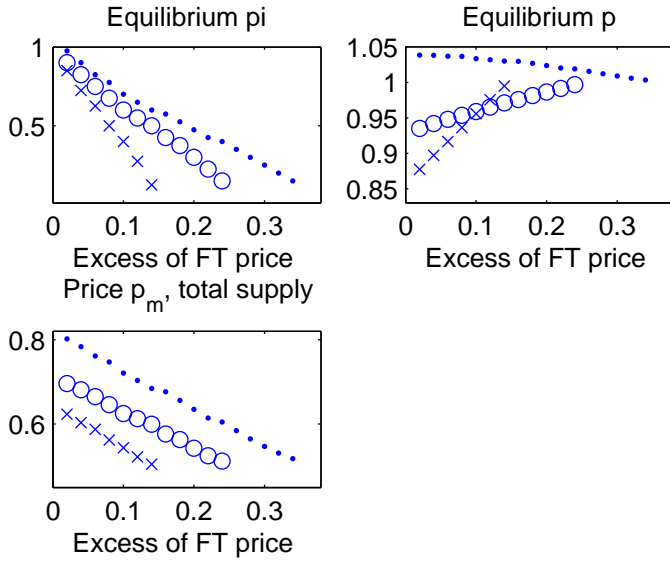
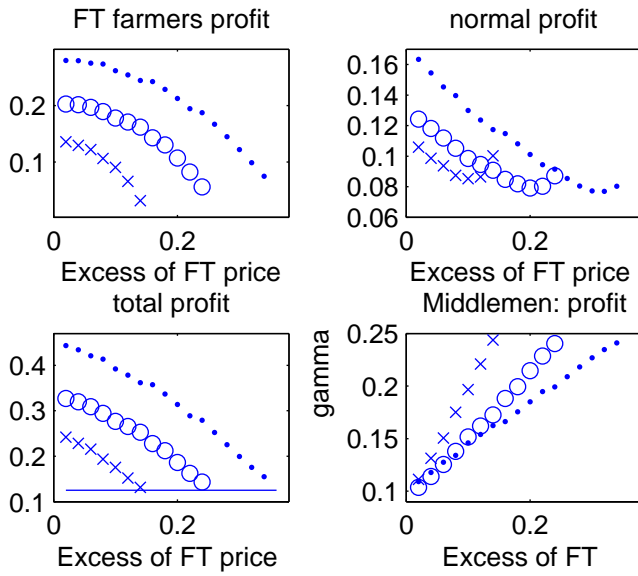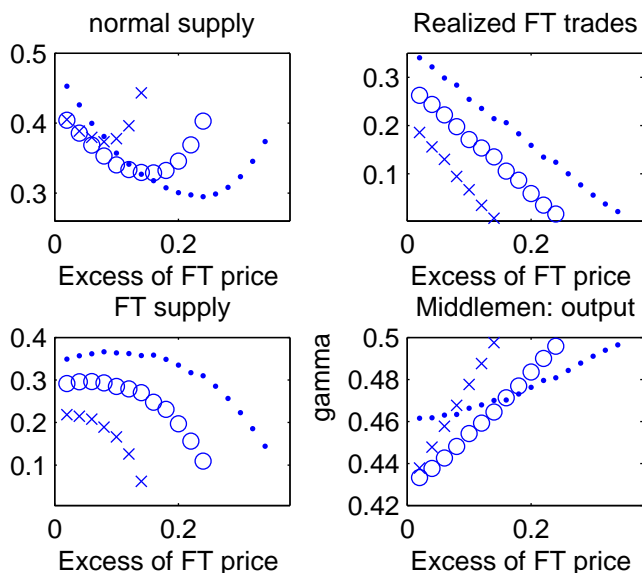Figure 2.3: Equilibrium prices.

Figure 2.4: Equilibrium profits.

Figure 2.5: Equilibrium quantities

in the Fair Trade scheme initially rises yet eventually decreases as the difference between the FT price p^F and the market-clearing price increases. At these levels, the Fair Trade participation declines sharply as many previously Fair Trade farmers now switch back to the normal coffee production. Given that the middlemen's purchase price p^M falls continuously, it is precisely this group of farmers that drive the postponed increase of the normal coffee supply.

The participation choices differ from the pattern of realized trades, since part of the Fair Trade harvest has to be sold through conventional markets. The plots labeled "Realized FT trades" and "Middlemen output" capture the actual volumes of trade transacted on each market. These plots again confirm that the greatest benefactor from the excess-supply regime are in fact not the farmers, but paradoxically the middlemen.

Summary of the results in the world with middlemen

In this section we focused on the effect of the introduction of the Fair Trade market and binding minimum price p^F in a setup with monopsonistic middlemen. Our results conform to the generally positive role for Fair Trade discussed in the previous section. Furthermore, they convey a number of additional conclusions that either complement or replace the non-middlemen setup.

First of all, the common claims that the excess supply caused by the binding minimum price policy of the FLO tends to depress world prices and thus the incomes of the non-participating farmers are not quite precise. The normal coffee price p might in fact *increase* due to the market failure in the distribution chain - the middlemen. Nonetheless, the impact on the non-participating farmers' incomes remains negative. The reason is that in the present setup there exist two channels through which Fair Trade affects the incomes of farmers. In comparison with the world without middlemen, the first channel has strengthened in that the Fair Trade market boosts incomes not only through the improved matching of farmers' output

with differentiated demand, but also by dampening the market power of the middlemen. The second channel, i.e. the negative impact of the minimum price p^F, has however likewise became stronger. The minimum contracting price policy now returns part of the market power back to the middlemen, who in fact become the greatest benefactors of this regime relative to the Fair Trade market with flexible price.

2.5   Conclusion

The recent success story of Fair Trade has provoked a lively debate on the scope and intensity of the scheme's actual benefits and shortcomings. We develop a simple framework and find that the introduction of a new Fair Trade market has the capacity to improve the living conditions of all farmers. The scheme's potential is not fully met, however, as the FTO's supplementary policy of a minimum contracting price brings about costs in terms of the lower-than-possible payoffs of the majority of farmers, the higher-than-necessary exit of the non-participating farmers from the coffee production, and less resources for community investment. The above equilibrium Fair Trade price can be justified merely as a policy of increasing farmers' participation within the Fair Trade scheme.

The major beneficiary of the minimum price policy are paradoxically the middlemen whose allegedly exploitative position stood at the very roots of the whole Fair Trade movement. In our numerical example we show that the middlemen use their monopsony position to appropriate part of the farmers' payoffs that would have been realized under the market-clearing setup. The excess supply thus allows the middlemen to exploit the farmers more than they could in the case of market clearing on the Fair Trade market. The profitability of the excess-supply regime for the middlemen also raises with the substitutability (as measured by γ) between normal and Fair Trade coffee. For a high degree of substitutability, one might even observe an increase in the world price of normal coffee p and a simultaneous decline in the living standards of normal farmers.

Our paper does not focus on certain aspects of Fair Trade, including the impact on migration and the local environment, self-governance, credibility or the nation-wide reallocation of resources. By no means do we claim that these concerns are of lesser or no importance. Nonetheless, given the absence of an integrated modelling approach, we focus on a specific area of interest and analyze it within a well-defined framework. This area relates to the distributional impact of the Fair Trade scheme.

The model's results should serve as a comment on the potential risks and limitations of the otherwise relatively successful Fair Trade scheme. It seems quite reasonable that the very existence of Fair Trade alleviates the informational asymmetry between "socially-conscious" Western consumers, distributors and farmers located in developing countries. Given that consumers value "fair" production, the absence of credible information and non-negligible fixed costs related to setting up markets hinders the functioning of the Fair Trade market and some sort of market intervention thus might be justified. Nonetheless, the scheme's optimal design remains an open question and we hope to provide at least a partial answer.

From the policy perspective, we agree that the guaranteed minimal p^F can take a number of other important roles such as insurance against volatile coffee prices or an improved outside option for the farmers participating in sharecropping agreements. Our results should rather be understood as a selective contribution to the debate on the benefits of alternative policy instruments. For example, the stability of Fair Trade prices can be achieved through other

instruments than a fixed minimum price. The related problem of the excess supply on Fair Trade markets can be addressed e.g. through the introduction of a pre-determined schedule and gradual replacement of established Fair Trade producers by their less experienced counterparts.

2.6 Appendix

2.6.1 Model without middlemen

Comparative statics

Proof of Lemma 2.3. To show that

$$\frac{d\pi}{dp^F} < 0, \frac{dp}{dp^F} < 0$$

take the total derivatives of the market equilibrium conditions and rearrange them to obtain

$$\left(S^F + \pi S_\pi^F\right) \frac{d\pi}{dp^F} + \left(\pi S_p^F - D_p^F\right) \frac{dp}{dp^F} = D_{p^F}^F - \pi S_{p^F}^F$$

$$S_\pi^{WN} \frac{d\pi}{dp^F} + \left(S_p^{WN} - D_p^N\right) \frac{dp}{dp^F} = D_{p^F}^N - S_{p^F}^{WN}$$

$$S^F = G\left(\pi\left(p^F - p\right)\right)$$

$$S^N = G(p) - G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$$

$$S^{WF} = \pi S^F = \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$$

$$S^{WN} = G(p) - \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right),$$

where

$$t = \frac{\pi\left(p^F - p\right)}{k}$$

$$S_\pi^F = g(t)\frac{p^F - p}{k}, S_p^F = -g(t)\frac{\pi}{k}, S_{p^F}^F = g(t)\frac{\pi}{k}$$

$$S_\pi^{WN} = -\pi\left(g(t)\frac{p^F - p}{k}\right) - S^F$$

$$S_p^{WN} = g(p) + \pi(g(t))\frac{\pi}{k}$$

$$S_{p^F}^{WN} = -\pi g(t)\frac{\pi}{k}.$$

Substituting for supply relationships and expressed in a convenient matrix form we obtain:

$$\begin{bmatrix} S^F + \pi g(t)\frac{p^F-p}{k} & -\left(g(t)\frac{\pi^2}{k}\right) + D_p^F \\ -\pi g(t)\frac{p^F-p}{k} - S^F & g(p) + \pi(g(t))\frac{\pi}{k} - D_p^N \end{bmatrix} \begin{bmatrix} \frac{d\pi}{dp^F} \\ \frac{dp}{dp^F} \end{bmatrix} = \begin{bmatrix} D_{p^F}^F - g(t)\frac{\pi^2}{k} \\ D_{p^F}^N + g(t)\frac{\pi^2}{k} \end{bmatrix}.$$

Note that the signs of the individual cells are unambiguous:

$$\begin{bmatrix} + & - \\ - & + \end{bmatrix} \begin{bmatrix} \frac{d\pi}{dp^F} \\ \frac{dp}{dp^F} \end{bmatrix} = \begin{bmatrix} - \\ + \end{bmatrix}.$$

Rearranging comparative statics one gets

$$\frac{d\pi}{dp^F} = \frac{D_{p^F}^F - g(t)\frac{\pi^2}{k}}{S^F + \pi g(t)\frac{p^F-p}{k}} + \frac{\left(g(t)\frac{\pi^2}{k}\right) + D_p^F}{S^F + \pi g(t)\frac{p^F-p}{k}}\frac{dp}{dp^F} \tag{2.5}$$

$$\frac{d\pi}{dp^F} = -\frac{D_{p^F}^N + g(t)\frac{\pi^2}{k}}{S^F + \pi g(t)\frac{p^F-p}{k}} - \frac{g(p) + \pi(g(t))\frac{\pi}{k} - D_p^N}{S^F + \pi g(t)\frac{p^F-p}{k}}\frac{dp}{dp^F}. \tag{2.6}$$

Equations (2.5) and (2.6) give us comparative statics in the FT market with the equilibrium values of $\frac{d\pi}{dp^F}$ and $\frac{dp}{dp^F}$. Of course, in the overall equilibrium both equations have to be satisfied simultaneously, which allows us to compute both $\frac{d\pi}{dp^F}$ and $\frac{dp}{dp^F}$.

   Given our demand assumptions, a closer look at the system tells us that

$$[\frac{D_{p^F}^F - g(t)\frac{\pi^2}{k}}{S^F + \pi g(t)\frac{p^F-p}{k}} < -\frac{D_{p^F}^N + g(t)\frac{\pi^2}{k}}{S^F + \pi g(t)\frac{p^F-p}{k}} \text{ and}$$

$$0 < \frac{\left(g(t)\frac{\pi^2}{k}\right) + D_p^F}{S^F + \pi g(t)\frac{p^F-p}{k}} < -\frac{g(p) + \pi(g(t))\frac{\pi}{k} - D_p^N}{S^F + \pi g(t)\frac{p^F-p}{k}},$$

because we assume that the direct price effect is stronger than the indirect one: $|D_{p^F}^F| > D_{p^F}^N$, $|D_p^N| > D_p^F$. This implies that the solution has to satisfy $\frac{d\pi}{dp^F} < 0$, $\frac{dp}{dp^F} < 0$. This is easy to see - while both relationships are not linear, the intercept of (2.5) is unambiguously lower than the intercept of (2.6), while the slope of (2.5) is positive yet not as steep as that of (2.6). This implies that both curves (given that they exist and are continuous, which we assume) can cross only in the 3$^\text{rd}$ quadrant,[32] or in other words

$$\frac{d\pi}{dp^F} < 0, \frac{dp}{dp^F} < 0.$$

---

[32] Alternatively, one can express $\frac{dp}{dp^F}$ from (2.5) and (2.6) to see that the sign has to be negative:

$$\frac{dp}{dp^F} = -\frac{\frac{D_{p^F}^F - \pi^2/k}{2S^F} + \frac{D_{p^F}^N + \pi^2/k}{2S^F}}{\frac{D_p^N - (1+\pi^2)/k}{2S^F} + \frac{\left(\pi^2/k + D_p^F\right)}{2S^F}} < 0.$$

Once this is established, one can infer that $\frac{d\pi}{dp^F} < 0$ from (2.5).

The impact of Fair Trade on farmers' payoffs and participation

Proof of Lemma 2.4. 1) In the excess-supply equilibrium, the farmers' participation in the Fair Trade scheme increases if and only if

$$\left| \varepsilon_{p^F}^{D^F} \right| < \left| \varepsilon_{p^F}^{\pi} \right| \text{ and } \left| \varepsilon_{p^F}^{D^N} \frac{S^{WN}}{S^{WF}} \right| < \left| \varepsilon_{p^F}^{\pi} \right|.$$

The payoffs of farmers participating in Fair Trade decrease unambiguously relative to the market-clearing case.

- We are interested in the sign of $\frac{dS^F(\pi,p,p^F)}{dp^F}$, where $S^F(\pi,p,p^F)$ corresponds to participation in the Fair Trade certification scheme.

In the excess-supply equilibrium with $\pi < 1$ it has to hold that

$$\pi S^F(\pi,p,p^F) = D^F(p,p^F)$$
$$S^N(\pi,p,p^F) + (1-\pi)S^F(\pi,p,p^F) = D^N(p,p^F),$$
$$\pi = \pi(p^F), p = p(p^F).$$

Consider an increase of p^F above its equilibrium value. In the new equilibrium, the realized FT supply πS^F has to match the FT demand D^F, hence it has to hold that

$$\frac{d\left[\pi S^F(\pi,p,p^F) \right]}{dp^F} = \frac{dD^F}{dp^F}$$

$$S^F(\pi,p,p^F) \frac{d\pi}{dp^F} + \pi \frac{dS^F(\pi,p,p^F)}{dp^F} = \frac{dD^F}{dp^F}$$

$$\frac{dS^F(\pi,p,p^F)}{dp^F} = \frac{1}{\pi} \left(\frac{dD^F}{dp^F} - S^F(\pi,p,p^F) \frac{d\pi}{dp^F} \right)$$

$$sign\left(\frac{dS^F(\pi,p,p^F)}{dp^F} \right) = sign\left(\frac{dD^F}{dp^F} - S^F(\pi,p,p^F) \frac{d\pi}{dp^F} \right)$$

$$sign\left(\frac{dS^F(\pi,p,p^F)}{dp^F} \right) = sign\left(\frac{dD^F}{dp^F} - \frac{D^F}{\pi} \frac{d\pi}{dp^F} \right).$$

Pre-multiplying the term in the brackets by $\frac{p^F}{D^F} > 0$, one gets

$$sign\left(\frac{dS^F(\pi,p,p^F)}{dp^F} \right) = sign\left(\frac{p^F}{D^F} \frac{dD^F}{dp^F} - \frac{p^F}{\pi} \frac{d\pi}{dp^F} \right) = sign\left(\varepsilon_{p^F}^{D^F} - \varepsilon_{p^F}^{\pi} \right).$$

Finally, since $\frac{d\pi}{dp^F}$ and $\frac{dD^F}{dp^F}$ are both negative, we have

$$\frac{dS^F(\pi,p,p^F)}{dp^F} > 0 \iff \left| \varepsilon_{p^F}^{D^F} \right| < \left| \varepsilon_{p^F}^{\pi} \right|.$$

- For the second part of Lemma 2.4 we use the fact that

$$
S^F = G\left(\frac{\pi\left(p^F - p\right)}{k}\right)
$$

$$
S^{WN} = S^N + (1-\pi)\,S^F = G(p) - \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right),
$$

hence

$$
sign\left(\frac{dS^F\left(\pi, p, p^F\right)}{dp^F}\right) = sign\left[\left(p^F - p\right)\frac{d\pi}{dp^F} + \pi\left(1 - \frac{dp}{dp^F}\right)\right].
$$

Take the total derivative of the normal coffee market equilibrium condition 2.1,

$$
\frac{d\left[S^{WN}\left(\pi, p, p^F\right)\right]}{dp^F} = \frac{dD^N}{dp^F}
$$

$$
\frac{d\left[G\left(p\right) - \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right)\right]}{dp^F} = \frac{dD^N}{dp^F}
$$

$$
\frac{1}{k}\left[\left(p^F - p\right)\frac{d\pi}{dp^F} + \pi\left(1 - \frac{dp}{dp^F}\right)\right] = -\frac{\left(D_p^N \frac{dp}{dp^F} + D_{p^F}^N\right)}{\pi g\left(\frac{\pi\left(p^F - p\right)}{k}\right)} + \frac{g(p)}{\pi g\left(\frac{\pi\left(p^F - p\right)}{k}\right)}\frac{dp}{dp^F} -
$$

$$
-\frac{G\left(\frac{\pi\left(p^F - p\right)}{k}\right)}{\pi g\left(\frac{\pi\left(p^F - p\right)}{k}\right)}\frac{d\pi}{dp^F},
$$

which implies

$$
sign\left(\frac{dS^F\left(\pi, p, p^F\right)}{dp^F}\right) = sign\left[\begin{array}{c} -\left(D_{p^F}^N + G\left(\frac{\pi\left(p^F - p\right)}{k}\right)\frac{d\pi}{dp^F}\right) + \\ \left(g(p) - D_p^N\right)\frac{dp}{dp^F}\end{array}\right].
$$

Knowing that $\frac{dp}{dp^F} < 0$, multiply the term in the brackets by $\frac{p^F}{\pi} > 0$ and

$$
\frac{G\left(p\right) - \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right)}{G\left(p\right) - \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right)} = 1
$$

to obtain

$$
sign\left(\frac{dS^F\left(\pi, p, p^F\right)}{dp^F}\right) = sign\left[(-1)\left(\varepsilon_{p^F}^{D^N}\frac{S^{WN}}{S^{WF}} + \varepsilon_{p^F}^\pi\right)\right].
$$

That is,

$$
\frac{dS^F\left(\pi, p, p^F\right)}{dp^F} > 0 \iff \left|\varepsilon_{p^F}^{D^N}\frac{S^{WN}}{S^{WF}}\right| < \left|\varepsilon_{p^F}^\pi\right|.
$$

2) In the excess-supply equilibrium without middlemen, the Fair Trade farmers' payoffs decrease unambiguously.

To show that the participating farmers' payoffs decrease unambiguously, note that

$$\frac{d\pi}{dp^F} < \frac{D_{p^F}^F}{G\left(\frac{\pi(p^F-p)}{k}\right)}$$

implies $\frac{dp}{dp^F} < 0$, so for more negative values of $\frac{d\pi}{dp^F}$ the change in farmer's revenues from FT becomes less and less favorable. In other words,

$$\frac{d\pi}{dp^F} = \frac{D_{p^F}^F}{G\left(\frac{\pi(p^F-p)}{k}\right)}$$

represents the marginal value of $\frac{d\pi}{dp^F}$ consistent with transition to a new equilibrium. Now

$$\frac{d\pi}{dp^F} = \frac{D_{p^F}^F}{G\left(\frac{\pi(p^F-p)}{k}\right)} \longrightarrow \frac{dp}{dp^F} = 0$$

and we have

$$\frac{d}{dp^F}\left(\frac{\pi p^F + (1-\pi)\,p}{k}\right) = \frac{1}{k}\left[\pi + \underbrace{\left(p^F - p\right)\frac{d\pi}{dp^F}}_{<0} + \underbrace{(1-\pi)\frac{dp}{dp^F}}_{<0}\right] =$$

$$= \frac{1}{k}\left[\pi + \underbrace{\left(p^F - p\right)\frac{d\pi}{dp^F}}_{<0}\right]. \qquad (2.7)$$

But we also know that for $\frac{d\pi}{dp^F} = \frac{D_{p^F}^F}{G\left(\frac{\pi(p^F-p)}{k}\right)}$

$$\left(p^F - p\right)\frac{d\pi}{dp^F} = -\frac{k D_{p^F}^F}{\pi g\left(\frac{\pi(p^F-p)}{k}\right)} + \frac{k}{\pi g\left(\frac{\pi(p^F-p)}{k}\right)}\frac{dD^F}{dp^F} - \pi,$$

so that

$$\frac{d}{dp^F}\left(\frac{\pi p^F + (1-\pi)\,p}{k}\right) = \frac{1}{k}\left[\pi + \underbrace{\left(p^F - p\right)\frac{d\pi}{dp^F}}_{<0} + \underbrace{(1-\pi)\frac{dp}{dp^F}}_{<0}\right] = \qquad (2.8)$$

$$\frac{1}{\pi g\left(\frac{\pi(p^F-p)}{k}\right)}\left[-D_{p^F}^F + \frac{dD^F}{dp^F}\right] = \frac{1}{\pi g\left(\frac{\pi(p^F-p)}{k}\right)}\left[D_p^F \frac{dp}{dp^F}\right] = 0, \qquad (2.9)$$

which is the best possible impact on the Fair Trade farmers' payoffs that is consistent with the excess-supply equilibrium.

Proof of Corollary 2.1.   Following the rise of the Fair Trade price, the participation in the Fair Trade scheme can increase despite the fall of the participating farmers' payoffs.

The total derivative of the Fair Trade participation equals

$$
\frac{dG\left(\frac{\pi\left(p^F - p\right)}{k}\right)}{dp^F} = \underbrace{g\left(\frac{\pi\left(p^F - p\right)}{k}\right)}_{>0}\left[\frac{d}{dp^F}\left(\frac{\pi\left(p^F - p\right)}{k}\right)\right] =
$$

$$
= \frac{1}{k}g\left(\frac{\pi\left(p^F - p\right)}{k}\right)\left[\frac{d\left(\pi p^F + (1 - \pi)\,p\right)}{dp^F} - \frac{dp}{dp^F}\right],
$$

where

$$
g\left(x\right) = \frac{dG(x)}{d(x)}.
$$

Hence the sign of the total derivative depends on the sign of the part in square brackets. Even if the Fair Trade payoffs decline after the move from $\pi = 1$, i.e.,

$$
\frac{d\left(\pi p^F + (1 - \pi)\,p\right)}{dp^F} < 0,
$$

the bracketed term can be positive since $-\frac{dp}{dp^F} > 0$.

2.6.2   Model with middlemen

Existence of equilibria with middlemen

In order to proceed with the analysis, we will assume that there exists an equilibrium in which both markets are active, and which generates market-clearing prices p and p^F, i.e. an equilibrium in which $\pi = 1$. This section informally discusses under which conditions the equilibrium will exist. We do not claim that these conditions are necessary, as the existence of the equilibrium is not of our primary interest. In particular, we discuss the price ranges for which one may hope to find an equilibrium.

The market-clearing conditions are

$$
\begin{aligned}
\text{FT market} \quad &: \quad D^F\left(p, p^F\right) = G\!\left(\left(p^F - p^M\right)/k\right) = S^F\left(p^F, p^M\left(p, p^F\right)\right) \\
\text{Normal market} \quad &: \quad D^N\left(p, p^F\right) = S^N\left(p^F, p^M\left(p, p^F\right)\right) = G(p^M) - G(\left(p^F - p^M\right)/k).
\end{aligned}
$$

Obviously, we may have equilibrium only if

$$
0 \leq S^F \leq 1, 0 \leq S^N \leq 1, S^F + S^N \leq 1.
$$

We will be interested in those equilibria in which both markets are active. In case of a uniform distribution $G(x) = x, g(x) = 1$, we can discuss a range of prices for which there might be an equilibrium.

$$
0 < S^F, 0 < S^N, S^F + S^N \leq 1.
$$

The last constraint can be expressed in the form

$$
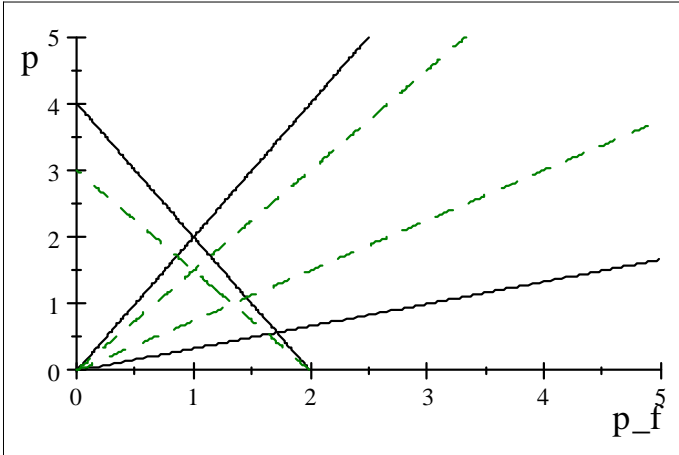\frac{p}{2} + \frac{p^F}{2\left(k + 1\right)} \leq 1.
$$

Figure 2.6: Participation constraints depending on p, p^F for $k = 1$ (full line) and $k = 0.5$ (dashed line).

The other two constraints are

$$(2k + 1)p^F - p(1 + k) > 0, p + kp - p^F > 0.$$

The possible combination of prices p, p^F is the triangle on the Figure 2.6.

We can see that if k decreases, which means that it is relatively cheaper for all farmers to produce FT coffee, the set of prices that might correspond to an equilibrium shrinks. This is an intuitive result - for very low k, it is cheap to obtain an FT certificate and thus prices on the regular market (p) must be close to the FT prices (p^F) in the market equilibrium. Note that this result holds in the excess supply equilibrium with appropriate modifications to the picture (p^F has to be replaced with πp^F on the supply side). The expected value from participation in the FT and regular markets must be similar if the participation costs in the FT market are low.

The impact of Fair Trade on farmers' payoffs and participation with the middlemen

Proof of Lemma 2.9. All farmers are better off if and only if the price p^M offered by the middlemen increases once the FT market opens. This happens if the overall demand for coffee does not fall substantially, i.e., if the world price of normal coffee p is relatively insensitive to the price of FT coffee p^F, or if it actually increases as a result of the new FT market. It is easy to observe that compared to the situation without Fair Trade, all farmers benefit only if the price of coffee set by middleman p^M increases and such increases indeed attract new farmers. If the price p^M decreases, some FT farmers might be better off than before, but there is a group of farmers who stop selling coffee altogether. These farmers lose, since in the absence of FT they used to make small yet positive profits. In general, the middleman's price p^M might move either way, because the movement of the price p is ambiguous and might dominate the other effects working through the Fair Trade price p^F or the success rate π. Nonetheless, it is

easy to show that for fixed p, price $p^{M\prime}$ in the world with an active FT market is larger than p^M when an FT market does not exist. To see this, compare the first order conditions of the middleman:

$$[\text{no FT}] : \qquad \left(p - p^M\right) g(p^M) - G(p^M) = 0$$

$$[\text{FT}] : \qquad \left(p' - p^{M\prime}\right) \left[g(p^{M\prime}) + \frac{1}{k}g\left(\frac{p^{F\prime} - p^{M\prime}}{k}\right)\right] - \left[G(p^{M\prime}) - G\left(\frac{p^{F\prime} - p^{M\prime}}{k}\right)\right] = 0.$$

It is obvious that once we plug in the values of p^M and p from the first line, the last element on the second line, $G(p^M) - G\left(\frac{p^F - p^M}{k}\right)$, is smaller than $G(p^M)$. Also, trivially $\frac{1}{k}g\left(\frac{p^F - p^M}{k}\right) > 0$. Thus, if we plug in p^M from the first FOC into the second and evaluate the sign, we see that

$$\left(p - p^M\right) g(p^M) - G(p^M) + \left(p - p^M\right) \frac{1}{k}g\left(\frac{p^F - p^M}{k}\right) + G\left(\frac{p^F - p^M}{k}\right) > 0 \qquad (2.10)$$

or alternatively,

$$\left(p - p^M\right) \left[g(p^M) + \frac{1}{k}g\left(\frac{p^F - p^M}{k}\right)\right] > \left[G(p^M) - G\left(\frac{p^F - p^M}{k}\right)\right].$$

Since the marginal gains in revenues from additional normal coffee purchases exceed the corresponding marginal costs for p^M from the world without Fair Trade, it is optimal for the middleman to raise the purchase price to $p^{M\prime}$. Thus the inequality implies that $p^{M\prime} > p^M$.

This argument requires that the first order condition of the FT market middleman is monotonic (unique local maximum) and that p is fixed. If the world price p is not very sensitive to the introduction of FT coffee (e.g., the FT market is small), then the argument holds by continuity (expression (2.10) remains positive for small changes in p). It is obvious to see that if p actually increases, then the argument holds as well, so the only case when it might not hold is when p decreases significantly as a result of the FT market opening. However, this can only happen once the overall world demand declines sharply after the introduction of Fair Trade, which is consistent with our results from Lemma 2.2 that dealt with world without middlemen. In fact, the results for the market-clearing case with middlemen are slightly stronger than those in Lemma 2.2. In the world with the middlemen, the non-participating farmers are better off even if the price of the normal coffee does not change. This happens as a consequence of the strategic behavior of the middleman, who finds it profitable to adjust her price p^M slightly in order to mute the outflow of farmers towards Fair Trade. Hence the non-participating farmers can fare better despite the possible fall of the normal coffee price p, given that the decline is not too sharp.

Comparative statics in the world with middlemen

Proof of Lemma 2.10.   Again, similarly to the excess supply analysis without middlemen we differentiate the whole system (2.4):

$$S^F \frac{d\pi}{dp^F} + \pi \left(S_\pi^F \frac{d\pi}{dp^F} + S_{p^M}^F \left(\frac{\partial p^M}{\partial p^F} + \frac{\partial p^M}{\partial \pi}\frac{d\pi}{dp^F} + \frac{\partial p^M}{\partial p}\frac{dp}{dp^F}\right) + S_{p^F}^F\right) \;=\; D_p^F \frac{dp}{dp^F} + D_{p^F}^F$$

$$S_\pi^{WN} \frac{d\pi}{dp^F} + S_{p^M}^{WN} \left(\frac{\partial p^M}{\partial p^F} + \frac{\partial p^M}{\partial \pi}\frac{d\pi}{dp^F} + \frac{\partial p^M}{\partial p}\frac{dp}{dp^F}\right) + S_{p^F}^{WN} \;=\; D_p^N \frac{dp}{dp^F} + D_{p^F}^N,$$

where S^{WN}_π is a partial derivative of S^{WN} with respect to π, for example.

Rearranging, one gets

$$\left(S^F + \pi S^F_\pi + \pi \frac{\partial p^M}{\partial \pi} S^F_{p^M} \right) \frac{d\pi}{dp^F} \quad + \quad \left(\pi S^F_p + \pi \frac{\partial p^M}{\partial p} S^F_{p^M} - D^F_p \right) \frac{dp}{dp^F} =$$

$$= D^F_{p^F} - \pi S^F_{p^F} - \pi S^F_{p^M} \frac{\partial p^M}{\partial p^F} \tag{2.11}$$

$$\left(S^{WN}_\pi + S^{WN}_{p^M} \frac{\partial p^M}{\partial \pi} \right) \frac{d\pi}{dp^F} \quad + \quad \left(S^{WN}_p - D^N_p + S^{WN}_{p^M} \frac{\partial p^M}{\partial p} \right) \frac{dp}{dp^F}$$

$$= D^N_{p^F} - S^{WN}_{p^F} - \frac{\partial p^M}{\partial p^F} S^{WN}_{p^M}. \tag{2.12}$$

We can plug in for $S^F, S^N, S^F, S^{WF}, S^{WN}$ and their derivatives:

$$S^F = G\left(\frac{\pi \left(p^F - p^M \right)}{k} \right)$$

$$S^N = G(p) - G\left(\frac{\pi \left(p^F - p^M \right)}{k} \right)$$

$$S^{WF} = \pi S^F = \pi G\left(\frac{\pi \left(p^F - p^M \right)}{k} \right)$$

$$S^{WN} = G(p^M) - \pi G\left(\frac{\pi \left(p^F - p^M \right)}{k} \right)$$

$$\pi S^F_\pi + \pi \frac{\partial p^M}{\partial \pi} S^F_{p^M} = g(t)\left(\frac{p^F - p^M}{k} - \frac{\pi}{k} \frac{\partial p^M}{\partial \pi} \right)$$

$$\pi S^F_p + \pi \frac{\partial p^M}{\partial p} S^F_{p^M} = -g(t) \frac{\pi^2}{k} \frac{\partial p^M}{\partial p},$$

$$\pi S^F_{p^F} + \pi S^F_{p^M} \frac{\partial p^M}{\partial p^F} = \pi g(t) \frac{\pi}{k} - \frac{\pi^2}{k} g(t) \frac{\partial p^M}{\partial p^F},$$

$$S^{WN}_\pi + S^{WN}_{p^M} \frac{\partial p^M}{\partial \pi} = g(p^M) \frac{\partial p^M}{\partial \pi} - \pi g(t)\left(\frac{p^F - p^M}{k} - \frac{\pi}{k} \frac{\partial p^M}{\partial \pi} \right) - S^F$$

$$S^{WN}_p + S^{WN}_{p^M} \frac{\partial p^M}{\partial p} = \left(g(p^M) + \pi g(t) \frac{\pi}{k} \right) \frac{\partial p^M}{\partial p}$$

$$S^{WN}_{p^F} + \frac{\partial p^M}{\partial p^F} S^{WN}_{p^M} = \left(g(p^M) + \pi g(t) \frac{\pi}{k} \right) \frac{\partial p^M}{\partial p^F} - \pi g(t) \frac{\pi}{k}$$

$$t = \frac{\pi \left(p^F - p^M \right)}{k}.$$

We can rewrite the equations (2.11) into matrix form

$$
\begin{bmatrix}
S^F + \pi g(t)\left(\frac{p^F - p^M}{k} - \frac{\pi}{k}\frac{\partial p^M}{\partial \pi}\right) & -g(t)\frac{\pi^2}{k}\frac{\partial p^M}{\partial p} - D_p^F \\
g(p^M)\frac{\partial p^M}{\partial \pi} - \pi g(t)\left(\frac{p^F - p^M}{k} - \frac{\pi}{k}\frac{\partial p^M}{\partial \pi}\right) - S^F & \left(g(p^M) + \pi g(t)\frac{\pi}{k}\right)\frac{\partial p^M}{\partial p} - D_p^N
\end{bmatrix}
\begin{bmatrix}
\frac{d\pi}{dp^F} \\
\frac{dp}{dp^F}
\end{bmatrix}
=
$$

$$
\begin{bmatrix}
D_{p^F}^F - g(t)\frac{\pi^2}{k} \\
D_{p^F}^N - \left(g(p^M) + \pi g(t)\frac{\pi}{k}\right)\frac{\partial p^M}{\partial p^F} + \pi g(t)\frac{\pi}{k}
\end{bmatrix}.
$$

Note that the signs of the individual cells depend on the size of $\frac{\partial p^M}{\partial \pi}$

$$
\begin{bmatrix}
+ & - \\
- & +
\end{bmatrix}
\begin{bmatrix}
\frac{d\pi}{dp^F} \\
\frac{dp}{dp^F}
\end{bmatrix}
=
\begin{bmatrix}
- \\
+
\end{bmatrix}
$$

$$
S^F + \pi g(t)\left(\frac{p^F - p^M}{k} - \frac{\pi}{k}\frac{\partial p^M}{\partial \pi}\right) \;>\; 0
$$

$$
-g(t)\frac{\pi^2}{k}\frac{\partial p^M}{\partial p} - D_p^F \;<\; 0
$$

$$
g(p^M)\frac{\partial p^M}{\partial \pi} - \pi g(t)\left(\frac{p^F - p^M}{k} - \frac{\pi}{k}\frac{\partial p^M}{\partial \pi}\right) - S^F \;<\; 0
$$

$$
\left(g(p^M) + \pi g(t)\frac{\pi}{k}\right)\frac{\partial p^M}{\partial p} - D_p^N \;>\; 0.
$$

From Lemma 2.9, we know that $\frac{\partial p^M}{\partial \pi} > 0$, so we need $\frac{\partial p^M}{\partial \pi}$ to be small for this result to hold. For notational simplicity, we will write

$$
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix}
\begin{bmatrix}
\frac{d\pi}{dp^F} \\
\frac{dp}{dp^F}
\end{bmatrix}
=
\begin{bmatrix}
E \\
F
\end{bmatrix}.
$$

To show that

$$
\frac{dp}{dp^F} < 0 \text{ and } \frac{d\pi}{dp^F} > 0
$$

is not possible, we need to show that if $\frac{d\pi}{dp^F} > 0$, then $\frac{dp}{dp^F} > 0$. To do this, we write

$$
A\frac{d\pi}{dp^F} + B\frac{dp}{dp^F} = E
$$

$$
C\frac{d\pi}{dp^F} + D\frac{dp}{dp^F} = F.
$$

We know that $A > 0 > C, D > 0 > B, F > 0 > E$. So if $\frac{d\pi}{dp^F} > 0, A > 0$, but $E < 0$, it must be that $B\frac{dp}{dp^F} < 0$ in equilibrium, which means, because $B < 0$, that $\frac{dp}{dp^F} > 0$. The same argument holds for the second equation: $F > 0$, the first element ($C\frac{d\pi}{dp^F} < 0$) is negative, so the second element on the second line must be positive. Since $D > 0$, it implies $\frac{dp}{dp^F} > 0$. So the previous results about the impossibility of $\frac{d\pi}{dp^F} > 0$ and $\frac{dp}{dp^F} > 0$ seem to be preserved.

Thus, we have the following combinations that are of theoretical interest:

$$\frac{dp}{dp^F} \; < \; 0, \text{ and } \frac{d\pi}{dp^F} < 0$$

$$\frac{dp}{dp^F} \; > \; 0, \text{ and } \frac{d\pi}{dp^F} < 0.$$

Other possibilities are either not interesting or impossible:

$$\frac{dp}{dp^F} \; > \; 0 \text{ and } \frac{d\pi}{dp^F} > 0 \text{ (not interesting)}$$

$$\frac{dp}{dp^F} \; < \; 0, \text{ and} \frac{d\pi}{dp^F} > 0 \text{ (not possible)}.$$

So one can see that an increase in FT price p^F leads to an increased excess supply, but the impact on the world price is ambiguous p.[33]

2.6.3   Aggregate farmers' profits

Proof of Lemma 2.6.   Unless the world price of coffee p increases significantly when the price of FT coffee increases, the aggregated profit of all farmers is decreasing in p^F above the market equilibrium.

Revenues of the farmers in the excess-supply regime without middlemen is

$$R = S^{WN}p + S^{WF}p^F = (S^N + S^F)p + \pi S^F(p^F - p),$$

$$S^F = G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$$

$$S^N = G(p) - G\left(\frac{\pi\left(p^F - p\right)}{k}\right)$$

$$R = G(p^M)p + \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right)(p^F - p).$$

The costs are slightly more complicated:

$$C = \int_0^t (k+1)cg(c)dc + \int_t^p cg(c)dc$$

$$C = \int_0^{p^M} cg(c)dc + k\int_0^t cg(c)dc,$$

$$t = \frac{\pi\left(p^F - p\right)}{k}.$$

These costs change with the change in p^F in the following way:

$$\begin{aligned}
\frac{dC}{dp^F} &= pg(p)\frac{dp}{dp^F} + ktg(t)\frac{\pi}{k}(1 - \frac{dp}{dp^F}) + ktg(t)\frac{p^F - p}{k}\frac{d\pi}{dp^F}, \\
&= pg(p)\frac{dp}{dp^F} + ktg(t)\left(\frac{d\pi}{dp^F}\frac{p^F - p}{k} + \frac{\pi}{k}\left(1 - \frac{dp}{dp^F}\right)\right).
\end{aligned}$$

---

[33]Note that the effect on the world price, even if theoretically predicted, is likely to be extremely small given the relative sizes of both markets. Thus, the result is more of a theoretical interest than a testable prediction.

The change in revenues is

$$\frac{dR}{dp^F} = \frac{dp}{dp^F}\left(G(p) + pg(p)\right) + \frac{d\pi}{dp^F}G(t)(p^F - p) + \pi(p^F - p)g(t)\frac{dt}{dp^F} + \pi G(t)\left(1 - \frac{dp}{dp^F}\right),$$

$$\frac{dt}{dp^F} = \frac{d\pi}{dp^F}\left(p^F - p\right)/k + \frac{\pi}{k}\left(1 - \frac{dp}{dp^F}\right).$$

Note that

$$\frac{dR}{dp^F} - \frac{dC}{dp^F} = \frac{dp}{dp^F}\left(G(p) - \pi G\left(\frac{\pi\left(p^F - p\right)}{k}\right)\right) + \frac{d\pi}{dp^F}\left(G(t)(p^F - p)\right).$$

Since $\pi \leq 1$ and $\frac{\pi(p^F - p)}{k} \leq p$ in an equilibrium, the outcome depends on the sign of $\frac{dp}{dp^F}$ and $\frac{d\pi}{dp^F}$. We have already shown that $\frac{d\pi}{dp^F} < 0$ in any relevant equilibrium. Thus, unless $\frac{dp}{dp^F} > 0$ and is large enough, the profit of all farmers is decreasing in p^F above the market equilibrium.

Proof of Lemma 2.7.   If the participation of FT farmers decreases as a result of an increase in p^F, then the overall FT farmers' profit decreases.

The revenue and costs of FT farmers:

$$\begin{aligned}
R &= G(t)(\pi p^F + (1 - \pi)p) = G(t)(kt + p) \\
C &= \int_0^t (k+1)cg(c)dc.
\end{aligned}$$

We can compute the derivatives:

$$\begin{aligned}
\frac{dR}{dp^F} &= g(t)(kt + p)\frac{dt}{dp^F} + G(t)\left(k\frac{dt}{dp^F} + \frac{dp}{dp^F}\right) \\
\frac{dC}{dp^F} &= (k+1)tg(t)\frac{dt}{dp^F}, \\
\frac{dt}{dp^F} &= \frac{d\pi}{dp^F}\left(p^F - p\right)/k + \frac{\pi}{k}\left(1 - \frac{dp}{dp^F}\right).
\end{aligned}$$

The difference is

$$\begin{aligned}
\frac{dR}{dp^F} - \frac{dC}{dp^F} &= g(t)(kt + p)\frac{dt}{dp^F} + G(t)\left(k\frac{dt}{dp^F} + \frac{dp}{dp^F}\right) - (k+1)tg(t)\frac{dt}{dp^F} \\
&= \frac{dt}{dp^F}g(t)\left(p - \pi\frac{p^F - p}{k} + kG(t)\right) + G(t)\frac{dp}{dp^F}. \qquad (2.13)
\end{aligned}$$

Note that

$$g(t)\left(p - \pi\frac{p^F - p}{k} + kG(t)\right) > 0,$$

and thus

$$\frac{dt}{dp^F} < 0, \frac{dp}{dp^F} < 0 \implies \frac{dR}{dp^F} - \frac{dC}{dp^F} < 0.$$

2.6.4 Small FT market - fixed p

We extend our analysis to the situation when the FT market is too small to impact the world price p of coffee. For example, we may assume that there is a large number of regions, but in only very few of them are farmers participating in Fair Trade. Middlemen, if present, adjust to the FT market only if there are FT farmers in their region.

Lemma 2.13 *If there are no middlemen, the Fair Trade market where the price is set to clear the market always helps the farmers.*

Proof. Since price p does not change, the number of active farmers $G(p)$ does not change. Those farmers who decide to sell on the FT market ($G(\frac{p^F-p}{k})$ of them) are all better off, because they could have stayed in the non-FT market

In the world where the FT market clears, but there are middlemen, the situation is slightly more complicated. Middlemen react to the FT market and thus alter the revenue of non-FT farmers. However, we have shown before that all active farmers are strictly better off if the price p^M increases and that this happens when p is not very sensitive to p^F. We can thus apply the same argument as in Lemma 2.9 here, because price p is assumed to be fixed. For fixed p, the argument is very intuitive - middlemen increase the price to attract more farmers to offset the loss from those who left for the FT market. This increase in price helps all non-FT farmers, but FT farmers are still better off than non-FT ones.

Lemma 2.14 *When the FT market clears, it helps all the farmers even if there are middlemen.*

Proof. See Lemma 2.9 and note that p is fixed.

In the case of the FT market with price p^F above market equilibrium (and thus $\pi < 1$), but no middlemen, we will analyze the impact of a small increase in p^F. Farmers benefit if the expected revenue, πp^F, increases. This happens when

$$\frac{\partial(\pi p^F)}{\partial p^F} = \frac{\partial \pi}{\partial p^F} p^F + \pi > 0$$

$$\frac{\partial \pi}{\partial p^F} > -\frac{\pi}{p^F}.$$

We can use market equilibrium conditions to prove the following result.

Lemma 2.15 *Farmers benefit from a marginal increase in p^F if and only if*

$$\frac{D^F_{p^F}(p, p^F) - \pi^2 g(t)/k}{G(t) + tg(t)} > -\frac{\pi}{p^F},$$

where $t = \pi \frac{p^F-p}{k}$.

Proof. We use comparative statics to show that

$$D^F(p, p^F) - \pi G(t) = 0$$

$$\frac{\partial \pi}{\partial p^F} = \frac{D^F_{p^F}(p, p^F) - \frac{\pi^2}{k} g(t)}{G(t) + tg(t)} < 0,$$

because $D_{p^F}^F < 0$. From the previous discussion, we know that farmers benefit from the FT market if $\frac{\partial \pi}{\partial p^F}$ is large enough:

$$\frac{\partial \pi}{\partial p^F} = \frac{D_{p^F}^F(p, p^F) - \frac{\pi^2}{k} g(t)}{G(t) + tg(t)} > -\frac{\pi}{p^F}.$$

The final case, excess supply on the FT market and middlemen on the normal coffee market, is slightly more complicated. Because of the middlemen, farmers don't get a fixed price p for their normal coffee but price p^M that in general depends on the price p^F. The equilibrium condition on the FT market is

$$D^F(p, p^F) \;=\; \pi G(t'),$$
$$t' \;=\; \pi \frac{p^F - p^M}{k}.$$

Lemma 2.16 *If middlemen never increase their price p^M more than the price on the FT market increased, $\frac{\partial p^M}{\partial p^F} < 1$, and they do not increase their price too much when the probability of success on the FT market increases:*

$$\frac{\partial p^M}{\partial \pi} < k \frac{t'}{\pi^2} \left(\frac{G(t')}{t'g(t')} + 1 \right),$$

then the probability of successful trade on the FT market decreases when the FT price increases.

Proof.   We can again use the comparative statics argument to show

$$\frac{\partial \pi}{\partial p^F} = \frac{D_{p^F}^F - \frac{\pi^2}{k} g(t')(1 - \frac{\partial p^M}{\partial p^F})}{G(t') + \pi g(t') \left(\frac{t'}{\pi} - \frac{\pi}{k} \frac{\partial p^M}{\partial \pi} \right)}.$$

Assuming that

$$\frac{\partial p^M}{\partial p^F} < 1, \frac{\partial p^M}{\partial \pi} < k \frac{t'}{\pi^2} \left(\frac{G(t')}{t'g(t')} + 1 \right),$$

and by observing that

$$G(t') + \pi g(t') \left(\frac{t'}{\pi} - \frac{\pi}{k} \frac{\partial p^M}{\partial \pi} \right) > 0 \iff \frac{\partial p^M}{\partial \pi} < k \frac{t'}{\pi^2} \left(\frac{G(t')}{t'g(t')} + 1 \right),$$

we can conclude that $\frac{\partial \pi}{\partial p^F} < 0$.

Note that this lemma also allows for the possibility that the probability of success on the FT market (π) is locally increasing in p^F. This happens when $\frac{\partial p^M}{\partial p^F}$ is very large and such a condition is rather intuitive. If middlemen increase the price relative to an increase in p^F, it is possible that more FT farmers switch back to regular coffee production. However, this effect has to be stronger than a decrease in demand by FT coffee consumers. It is clear that such a case is very unlikely.

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Chapter 3

How to Price Imperfect Certification

Abstract:

This paper analyzes markets in which consumers do not directly observe the quality of the products but form their expectations about the quality based on the outcome of voluntary imperfect certification. I analyze how the certification fee impacts the decisions of the producers to apply for a certificate and whether to supply goods of the required quality. I find that there are both separating (only high quality producers apply for and obtain the certificate) and pooling (both high and low-quality producers apply for and obtain the certificate) equilibria. I show that the pooling equilibrium exists when the certification fee is low, while the separating equilibrium requires high certification fees. Since the pooling equilibrium is not welfare optimal, low certification fee is not always beneficial. This result complements Strausz (2005) who shows that high certification fees are required to prevent corruption of the certifier.

Keywords: certification, imperfect testing technology, competition, adverse selection
JEL Classification: D43, D45, D82

3.1   Introduction

Certification systems are widely used to solve problems arising in situations of asymmetrical information. In particular, when consumers purchase a product infrequently or learning the quality is very costly, a certification system may lead to more efficient information transmission, because it replaces the need for individual consumer learning with a single certification test for producers. Typically, there is a single certifier, who tests all applying producers and assigns a single certificate to successful applicants (Lizzeri, 1999). However, there are also several certification systems in which the owner of the certificate accredits several competing firms, who conduct the tests in its name (organic farming, automobile emissions testing), possibly to lower the price of these tests. It is not known, neither theoretically nor empirically, whether such attempts to lower the certification fee are in fact beneficial.

The example that motivates this research comes from the structure of organic farming certification. A producer may use the word "organic" (in the USA) or "BIO" (in the EU) on

his product only if he obtains a certificate from an accredited certifier. Governments often accredit several firms (about two dozen in Germany and fifty-five in the USA). Even though certifiers may use their own label, I will later argue that it seems likely that consumers do not establish the reputation of individual certifiers because there is a large number of them, in contrast with a single, unified label "organic".

While this market structure creates new incentive problems regarding the necessary investment into the quality of testing,[1] it is not clear that even reducing the certification fee is welfare improving for a fixed quality of testing. The reason for this somewhat surprising possibility is that the certification fee also helps separate high and low-quality producers.[2] To understand when lower certification fees benefit society, caused for example by more competition between certifiers, I study the effect these fees have on the entry decision of low and high-quality producers.

These results should serve as a caution for the regulators of existing certification systems. As these systems grow, the need for cheaper certification sometimes leads to calls for more competition between certifiers. The competition between certifiers may be useful, as it reduces monopoly rents that a single certifier is able to extract. However, excessive competition that reduces the price of certification may lead to the entry of low-quality producers and harm the trust of consumers in the certification systems. Price competition may result in the presence of low-quality producers among the certified. A potential remedy for this problem is to improve the quality of testing by stricter supervision (or accreditation) of the certifiers.

This paper complements Strausz (2005) who shows that the certification fee has to be high enough to discourage the certifier from accepting bribes from producers, using a repeat-purchase mechanism similar to Klein and Leffler (1981).

3.2   Certification of organic products

Organic food, believed by many to be healthier due to low or no content of pesticides, has witnessed significant growth in the recent years. As organic products became available in most supermarkets, the volume traded and the acreage of land producing organic products grew significantly. Total acreage quadrupled from 1995 to 2005 in the USA alone, from about 1 million acres to 4 million (USDA, 2008e). The Organic Trade Association (2007) claims that average yearly growth over the past ten years reached almost 20% and the total volume of consumer sales reached $17.7 billion. It estimates that organic sales account for about 2.8% of total food sales, with significantly faster growth.

This success lead to some questions about the meaning of the "organic" label (New Yorker, 2006). Both the European Union and the USA regulate organic production. They require that producers of organic products (farmers and processors) obtain a certificate before they label products as organic.[3]   Certificates can be obtained from accredited certifiers.   Such

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[1]If there are several certifiers among whom consumers do not distinguish, low-quality certification has negative externalities on other certifiers. This suggests that certifiers may lack sufficient incentives to carefully test applicants or to invest into testing technology, because they pay all the costs but benefit only partially due to the shared reputation with other certifiers.

[2]This results has been also shown by Svitkova and Ortmann (2006) in a somewhat different setting. They focus on how the choice of standards and fees by a certifier depends on its objective function when the distribution of the quality of producers is fixed. This paper takes standards and fees as given and focuses on how the choice of quality by producers depends on the quality of the testing procedure and fee for certification.

[3]In the USA, there are several categories with varying strictness (USDA, 2008b). Labeling requirements

accreditation is provided by the USDA or the national governments in the EU. There are currently 55 accredited certifiers in the USA. In the EU, each state accredits local certifiers, but their certificates have EU-wide validity. It is possible to find only public certifiers in certain member states and a number of competing private certifiers in others (European Commission, 2005a). For example, Germany has currently 23 accredited private certifiers, while the Netherlands has just one public certifier.

The certification process is costly and long, especially for farmers. Any farm interested in producing organic products must enter a so-called transitional phase that lasts several years (USDA, 2008d) during which the use of pesticides and other chemicals must fulfill organic label criteria, yet products cannot be yet sold as organic. Regulation requires at least one on-site inspection by a certifier every year, but also allows an unlimited number of additional visits in case the certifier considers such visits necessary or suspects any wrongdoing. Apart from certification costs, there are additional production costs related to organic food production. For example, organic farming is claimed to have a lower yield and to require more labor than traditional farming. On the other hand, there are subsidies for organic farmers that aim to partially offset these extra costs. Since the organic products are sold at significantly higher prices, these subsidies most likely do not fully cover these costs and "organic" production remains more expensive than traditional production.

While the law specifies what is allowed in "organic" production and what is not, it does not specify the details of certification. While regulation requires that certifiers collect any samples[4] (water, soil, seeds, plants) necessary to ascertain that forbidden substances are not used on a farm applying for the organic certificate, it leaves the interpretation of this requirement to the certifiers. A modification of the current rules suggested by public interest groups to require at least 5% of unannounced visits every year was rejected by the USDA because they "believe the certifying agent is in the best position to determine the need for additional on-site inspections" (USDA, 2008a). Thus, the certifiers have a significant leeway in enforcing the standards.

Surprisingly little is known about the supervision of certifiers. Typically, governments list the requirements for the certifiers to become accredited and their initial evaluation. These requirements are education, experience and expertise, necessary knowledge, and technical equipment. Some governments also stipulate that certifiers cannot themselves be producers of organic food, nor can they certify producers located in the same city as themselves. While this somewhat limits the potential conflicts of interests, it is no panacea. It seems that the USDA relies on the complaints from the public to monitor the behavior of certifiers. However, complaints against farmers are referred to the certifiers and only complaints made against certifiers are dealt with by the USDA. Their website shows only one case of suspension or revocation of an accreditation of a certifier (USDA, 2008c).[5]

Governments typically require that a name (USA) or a unique identifier (EU) of a certifier is present on most goods, exempting fruits and vegetables sold in bulk. This allows, at least

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differ based on the statements on the product. Requirements for retailers in the USA are explained in detail in USDA (2008d).

[4]A report by the European Commission (2005b) shows an interesting diversity in the number of samples collected. While in Belgium, the number of samples reaches 60% of the total number of certified "operators", there is a large number of EU members where the percentage is close to zero (about 1%).

[5]There are no cases known to me in the European Union. However, this lack of evidence should not be construed as proof of absence of such cases. Each member state accredits and monitors its own certifiers, which makes it difficult to verify the number of cases for all member states.

in theory, each consumer to establish the reputation of each certifier. I argue that such an outcome seems unlikely for any significant portion of consumers, and I will assume in the model that all certifiers share only the label "organic". The justification for such an assumption comes primarily from the large number of certifiers that each consumer may be facing. Not only governments accredit several national certifiers, foreign certifiers are also often allowed to sell their products as organic. This increases the number of potential certifiers to several dozens. Moreover, consumers are often unable to evaluate the "organic" quality themselves without incurring significant costs. In the case of the whole "organic" market, consumers might form a reasonably precise estimate of quality of the organic testing based on word-of-mouth, consumers testing or governmental reports, which might guarantee sufficient flow of information. The information flow about each certifier may be smaller by an order of magnitude. Additionally, careful observation of all information about all relevant certifiers might be costly to the consumer.

Even though there is no direct evidence to support the assumption that certifiers do not have a significant individual reputation, I will assume so for the sake of simplicity and clarity of the model and its results. Thus, I can study the impact of the certification on market outcomes and welfare.

3.3   Literature review

Certification as a solution to asymmetrical information problems was offered as a potential remedy for Akerlof's (1970) "lemon" problem by Viscusi (1978). Further research focused mostly on models with perfect testing technology.

Lizzeri (1999) explains a puzzle: Certifiers typically award a single certificate as a document of "passing" the tests, even though they learn more information during the test, which they do not reveal. Lizzeri shows that awarding a single certificate to successful applicants is in fact a profit maximizing strategy of a certifier. He also shows that it is a unique strategy when the expected value of the product to the consumer is negative.

Biglaiser and Friedman (1994) show that middlemen, who purchase goods from various producers and sell them to consumers can in fact take the role of a certifier. The reputation building mechanism in this case is based on the loss on sales of other products. If a middleman attempts to cheat its consumers, he is punished by reduced sales on other products. This mechanism makes middlemen more trustworthy than a producer of one product line.

Strausz (2005) builds a model of certification where individual producers have exogenously given quality, a certifier has perfect technology and upon testing, learns and reveals the true quality. Consumers are able to learn the quality after consumption. In such a situation, a certifier is able to build its reputation, similarly as in Klein and Leffler (1981), if a certification fee is high enough to overcome the temptation to certify low-quality producers as being of high quality for a bribe. Strausz also shows that the honesty of a certifier can be assured at the lowest possible price only if the whole market is served by a unique certifier.

My model differs from Strausz's in several key aspects, but complements his results. While he focuses on the moral hazard problem of the certifier, I focus on the adverse selection of low-quality producers. Strausz studies the incentives of a certifier to resist the temptation of bribes; I study the impact of competition on the entry of high/low-quality producers. I will show that the price of certification may be too low to prevent the entry of low-quality producers.

I assume that consumers cannot be systematically cheated (in a rational expectations equilibrium) because they correctly expect the probability that certified products are organic. I show that in the case of imperfect testing technology, low certification fees make the attempts to obtain a certificate by non-organic farmers more attractive, which reduces the quality of the certificate and welfare. Similarly to Strausz, I do not explicitly model the competition, but I formally model only the impact that lower fees and lower quality testing technology have on the long-run equilibria.

Thus, I show that lower certification fees, possibly as a result of competition between certifiers, are not beneficial because of the behavior of the producers. This is a complement to Strausz's results that low certification fees make the honesty of the certifier less likely.

Little is known about what impact an imperfect testing technology has on market outcomes, with the notable exception of two studies.

Svitkova and Ortmann (2006) study the role of the objective function of the certifier, who can set the price of certification, quality and required quality standards, to screen a fixed distribution of agents (charities in their case). In a situation where profit-maximizing certifiers set zero standards and extract rents without actually testing the applicants, not-for-profit certifiers choose positive standards, test the applicants, and thus achieve a separation of high- and low-quality charities, even though the separation is imperfect. Due to the complexity of such a model, their results are numerical. Even though our models are similar in spirit, I do not impose any objective function on the certifier, and I focus on the role of the certification fee and quality of testing on the participation decisions of the producers. In contrast to the analysis of not-for-profit charities, I focus on profit-maximizing producers. I also assume that consumers are heterogeneous, and quality can have only two levels (low and high).

A study by De and Nabar (1991) analyzes imperfect yet efficient testing technology, ie., the technology that makes high-quality producers more likely to pass the test. They assume that the certifier informs consumers also about producers who applied for but failed the test. This creates three categories of producers: those who applied and succeeded, applied and failed, and did not apply at all. Because of these three categories, they do not find a separating equilibrium. In a separating equilibrium, only high-quality producers would apply for a certificate, and thus both "failed" and successfully certified producers would be able to sell their products for high prices equal to the valuation of a high-quality good.[6] Any low-quality producer has the incentive to apply for certification because even failed application results in a high price for his good. Thus, there cannot be a separating equilibrium in such a model. In contrast, I assume that the certifier reveals only successful applicants. In such a market, the failed applicants sell in the market with producers who did not apply for a certificate. A separating equilibrium may exist if the probability of failure of the low-quality producer or the certification fee is sufficiently high.

The models also differ in additional assumptions and the focus of the analysis. I assume heterogeneous consumers and endogenous entry both for high and low quality producers. Moreover, I assume that high-quality producers have positive production costs, while De and Nabar assume zero production costs for all producers. Finally, I assume an unlimited number of potentially low-quality producers applying for certification, while De and Nabar assume a fixed number and distribution of quality of producers.

Even though surprisingly little was published on the topic of competition between certi-

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[6]Consumers are assumed to have rational expectations, and thus they would correctly expect both failed and successful producers to sell high-quality products.

fiers, there is some unpublished research available. A model of "Kosher Wars", certification of kosher food by Rabbis, is studied by Epstein and Gang (2002). Their model studies the choice of the standards of certificates in a situation when consumers are able to distinguish between different certifiers (each has his own "label"). The authors find that increasing the number of congregations increases the standards. It is not clear that this is a result of competition because more congregations implies more certifiers as well as more potential consumers.

Finally, a paper by Franzoni (1998) studies Cournot-like competition between certifiers with endogenous quality of testing technology. The author makes a few very significant assumptions that make the model easily tractable, yet somewhat unrealistic. Most importantly, he assumes that the payoff to certified producers does not depend on the number of certified producers or even on the average quality of the certified products. This implies that consumers are systematically being fooled or are not behaving rationally. Even though there is an explicit form of supervision by the government (in the form of the imperfect liability of certifiers), certifiers are not interested in the quality of the label. In contrast, I believe that certifiers are somewhat motivated by the success of their certificates, yet when they share the certificate with competitors, these incentives may not be sufficient. I also focus on rational expectations equilibria, in which consumers expect average quality of certified products correctly. I do not model competition between certifiers explicitly and instead focus on the impact that certification fees have on the entry of low and high-quality producers.

3.4   Model

I present a simple model of certification, whose structure is motivated by the leading example of organic farming. I start with a description of the demand side.

3.4.1   Consumers

I assume that there is a measure A of consumers, uniformly distributed along interval $[0, A]$, where $x \in [0, A]$, represents the value of a high quality (organic) product for this consumer. The value of low quality (regular) products is normalized to zero for all consumers. When the price of a high quality product is p, all consumers with valuation $x \geq p$ will purchase it. The demand is thus $A - p$ for high quality products.

I assume that consumers are not able to distinguish the quality of the products. Thus, in the case where consumers purchase on the market where both high and low quality products may be traded but cannot be distinguished (i.e., for example when both high and low quality products are certified due to mistakes in certification), the demand depends on the probability s with which a consumer expects a product on this market to be of high quality. A consumer of valuation x paying p for a product that is of high quality with probability s is willing to purchase the product if

$$sx + (1 - s)0 - p \geq 0.$$

The demand in such a situation would be then $A - \frac{p}{s}$. I analyze the rational expectations equilibria in which the consumers' expectations about s are correct.

3.4.2   Producers

I assume that there are two types of potential producers. First, there is a potentially unlimited (much larger than A) supply of producers who may produce only low quality products at

zero cost. Second, there exists a measure A of producers, uniformly distributed along interval $[0, A]$, who may produce both low and high quality products. The position $t \in [0, A]$ along the interval describes the production costs of high quality products for this producer. Production costs of low quality products are zero for all producers. Each producer makes one or zero units of the good.

3.4.3 Two markets

There are two competitive markets,[7] based on what consumers can observe. They cannot observe the quality of the products but they observe whether a product is certified or not. On the market of products without any certificate, the price has to be zero, because of the potentially unlimited supply of low quality producers and zero entry costs to this market. The price of goods on the certified market may be of course positive.

I denote a measure s_h of high quality producers that obtain a certificate and sell their products on the certified market. If no producers of low quality products obtain a certificate and thus there are no certified low quality products, the probability that a certified product is of high quality is equal to 1. However, if there is a positive measure of low quality products with a certificate, the probability is lower than 1. In fact, the probability,[8] which will be denoted by s, can be computed as

$$s = \frac{s_h}{s_l + s_h}.$$

In case there are no products on the market of certified products (both s_h and s_l are equal to zero), I set $s = 0$.

3.4.4 Certification

To obtain a certificate, producers must undergo an imperfect (noisy) testing procedure that costs f. For simplicity, I assume that mistakes happen with probability $q < \frac{1}{2}$. There can be two types of mistakes—low quality products may obtain a certificate and high quality producers may fail the test.[9] Later, I extend the analysis to allow asymmetric errors. The quality of testing technology, together with the number of high and low-quality producers applying for a certificate will determine the "quality" of a certificate, i.e., the probability s that a certified product is in fact of high quality. All players are assumed to be risk neutral.

For the following analysis, I assume that the fee for certification f and quality of the testing q are given exogenously. That is, the decisions of the certifiers is not explicitly modelled. Instead, I study how different fees and the quality of testing technology affect market outcomes and welfare.

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[7]The assumption that markets are competitive is reasonable due to the large number of producers and consumers.

[8]A formally correct definition would require a complete specification of the sample space, σ-algebra and measure P on this set. Defining standard Borel algebra on the set of real numbers $[0, s_h + s_l]$ and setting the appropriate measure would be sufficient. I omit the details.

[9]I also abstract from the legal enforcement of such restrictions and simply assume that no producer uses the label without such a certificate. Even in the case where the owner of the label is not a government, there is usually a sufficient legal protection (trademarks, etc.) that prevents producers from mis-using the certificate.

3.4.5   Three equilibria

Three types of equilibria exist. First, if the certification fee f is very high, neither high nor low quality producers will apply, and no certified products will be traded. The other two equilibria are more interesting.

The participation of high quality producers depends on price p for which certified products are sold, the probability that they will obtain a certificate, and the costs of certification and production. Marginal high-quality producers have production costs s_h

$$(1 - q)p - f - s_h = 0,$$

assuming that an outside option has zero value. Since all producers able to produce high quality goods with lower costs than s_h will apply for a certificate and produce the goods, the measure[10] of such producers is thus $(1 - q)p - f$. There are no high-quality producers selling organic products without a certificate since such products would be indistinguishable from (a large number of) low-quality products and of zero price.

Since the testing technology is noisy and high quality production is expensive, some low-quality producers may attempt to obtain a certificate. If these producers expect positive profit $pq - f > 0$ from such an attempt, they will apply, until the expected profits return to zero.

If expected profit of low-quality producers attempting to obtain a certificate is negative

$$pq - f < 0,$$

there will be only high-quality producers applying for a certificate in equilibrium. Note that any applicant has to pay a fee, regardless of whether he obtains a certificate or not. This is in fact how most certification systems work.

I analyze these types of equilibria separately, starting with the pooling one, in which some low and high quality producers apply for a certificate. If the certification is too costly ($f > A(1 - q)$), there is no certification in the equilibrium. The other two types are more interesting: a pooling and a separating equilibrium.

Pooling equilibrium

Since the expected profit on the uncertified market is zero, all low-quality producers have to be indifferent between applying for a certificate and low-quality production. Market equilibrium conditions then determine how many low-quality producers will apply. These conditions are:

- The participation of high quality producers

$$(1 - q)p - f - s_h = 0. \tag{3.1}$$

- Zero profit of low-quality producers

$$pq - f = 0. \tag{3.2}$$

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[10]If the following expression is smaller then zero for certain values of q, p and f, the measure is defined to be equal to zero, since no high quality producer will find it worth applying for a certificate and producing the high quality goods. One can see on the figure 3.1 when this happens.

- A definition of quality for the certificate (the probability that a product with a certificate is in fact of high quality), depending on the probability of mistake q is

$$s = \frac{(1-q)s_h}{(1-q)s_h + qs_l}. \tag{3.3}$$

- Finally, the market equilibrium on the certified products market requires

$$A - \frac{p}{s} = (1-q)s_h + qs_l, \tag{3.4}$$

where s_l is a measure of low-quality producers applying for a certificate, and s_h is a measure of high-quality producers. If the only solution of these equations is such that $s \notin [0,1]$, then the equilibrium does not exist.

Lemma 3.1 *For any quality of testing technology $q \in (0,0.5)$, fee f^* exists such that for any f, $0 < f < f^*$, there is an equilibrium with a positive measure of low-quality producers attempting to obtain a certificate, where*

$$f^* = A\frac{q}{2q^2 - 3q + 2}.$$

This function is increasing in q in the equilibrium. The equilibrium is described by equations

$$s_l = \frac{(1-2q)(1-q)}{q^2(2-3q+2q^2)}\left(Aq - f(2-3q+2q^2)\right), \tag{3.5}$$

$$s_h = f\frac{1-2q}{q}, \tag{3.6}$$

$$s = \frac{f}{Aq}\left(2q^2 - 3q + 2\right), \quad and \tag{3.7}$$

$$p = \frac{f}{q}. \tag{3.8}$$

When the testing technology is perfect $(q = 0)$, no low-quality producers will enter even if it is costless to do so. As the technology becomes more imperfect, the chances of success increase, and thus low-quality producers are willing to pay more for an attempt to get a certificate.

Separating equilibrium

There is a separating equilibrium in which no low-quality producers apply for a certificate because the expected profit from doing so is negative. In this equilibrium, the certification perfectly separates high- and low-quality producers. I assume that high-quality producers still fail certification tests with probability q. This assumption implies that certifiers do not observe that only high-quality producers are applying for the certificate or are unable to skip the testing. Thus, they conduct the tests of the same quality as when some low-quality producers are applying.

Since there are no low-quality producers applying in a separating equilibrium, all certified products are of high quality $(s = 1)$. Since mistakes happen with probability q, only $1-q$ share

of applying producers will obtain a certificate despite the fact that they are all high-quality producers.[11] The market equilibrium conditions are

$$A - p = (1 - q)s_h, \tag{3.9}$$
$$(1 - q)p - f - s_h = 0. \tag{3.10}$$

The constraint of this equilibrium is that the expected profit of low-quality producers is not positive

$$qp \leq f.$$

One can show that the condition that guarantees the existence of separating equilibria is complementary to the existence of the condition of pooling equilibria.

Lemma 3.2 *A lower and upper boundary on fee f exists so that an honest equilibrium exists only for f between these boundaries. I denote the lower boundary by f^* and the upper boundary f^{**}. It holds that*

$$f^* = A\frac{q}{2q^2 - 3q + 2},$$

and

$$f^{**} = A(1 - q),$$

The price of organic products in the honest equilibrium is $p = \frac{A + f(1-q)}{(q-1)^2 + 1}$. The number of high-quality producers applying for a certificate is

$$s_h = \frac{A(1 - q) - f}{(1 - q)^2 + 1}.$$

These results are summarized in the following corollary.

Corollary 3.1 *For a combination of (f, q) such that $f < A(1 - q)$, a unique equilibrium exists.*

- *If $f < A\frac{q}{2q^2-3q+2}$ in this equilibrium[12] some low-quality producers apply for a certificate.*

- *If $f \geq A\frac{q}{2q^2-3q+2}$, then no low-quality producers apply, and thus, all certified products are of high quality.*

- *If $f > A(1 - q)$, then no producers apply for a certificate in the equilibrium.*

The partition of the parameter space is depicted on the figure 3.1.

Note that the equilibria coincide for $f = A\frac{q}{2q^2-3q+2}$. There are no low-quality producers applying, but the their expected value of entry is zero. For $f > A\frac{q}{2q^2-3q+2}$, the expected value for low-quality producers is strictly negative.

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[11]This requires that certifiers are committed to do the tests. Without this commitment, there would be no separating equilibrium.

[12]In a pooling equilibrium, there is an additional constraint $p < A$, which is equivalent to $f < Aq$. This constraint is not binding because $2q^2 - 3q + 2 > 1$, and thus, I have
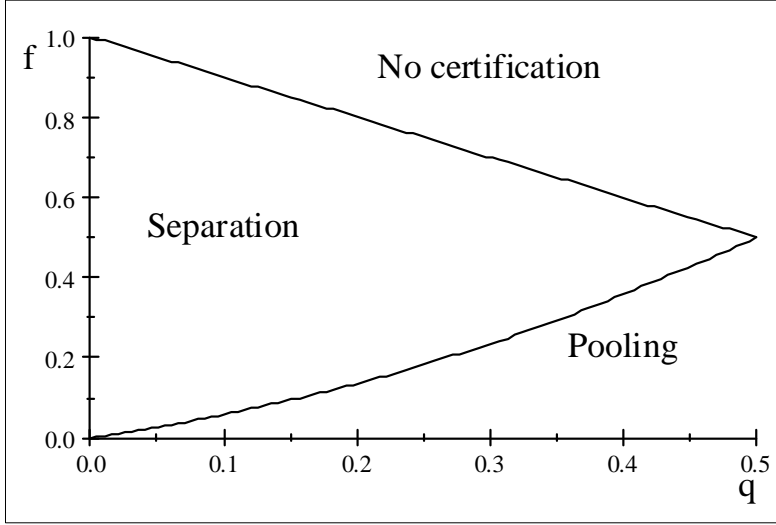
$$f \leq A\frac{q}{2q^2 - 3q + 2} < Aq.$$

Figure 3.1: Equilibria depending on certification fee f and probability of mistake q.

3.4.6 Welfare

In the previous section, I have shown that the certification fee determines whether low-quality producers will apply for a certificate. For a fee sufficiently low, they will find it profitable to do so. Yet, it is not obvious whether the benefits of a lower certification fee for high-quality producers and consumers exceed the loss from low-quality products being certified. This section analyzes where the welfare optimum lies.

I compute the welfare by finding consumers' surplus and producers' production costs. For simplicity, I assume that low-quality products have zero value and that high quality producers that do not obtain a certificate by error will sell their products to consumers who do not value it. For now, I also assume that the testing technology is costless and certification fees are thus mere transfers.

The welfare function is then

$$W = \frac{1}{2}\left(sA^2 - \frac{p^2}{s} - s_h^2\right),$$

which in a separating equilibrium is

$$W^s = \frac{1}{2\left(q^2 - 2q + 2\right)}\left(A^2\left(1 - q\right)^2 - f^2\right). \tag{3.11}$$

In a pooling equilibrium, it becomes

$$W^p = \frac{1}{2}\frac{f}{q^2}\frac{\left(1 - 2q\right)^2}{2q^2 - 3q + 2}\left(A\frac{q\left(1 - q\right)}{1 - 2q}\left(3 - 3q + 2q^2\right) - f\left(2 - 3q + 2q^2\right)\right). \tag{3.12}$$

The following results summarize the behavior of welfare.

Lemma 3.3 *Welfare in a separating equilibrium is decreasing in fee f, but increasing in f in a pooling equilibrium.*[13] *Since the equilibria coincide for $f^* = A\frac{q}{2q^2-3q+2}$, this is where the welfare is maximized. Welfare is increasing in quality q in both equilibria. When no certification takes place, welfare is zero.*

This result has an intuitive explanation. It is obvious that welfare improves when the certification fee is reduced in a separating equilibrium. In a pooling equilibrium (or at the border between a pooling and a separating equilibrium), when the certification fee is reduced, more low quality producers find it profitable to enter the market, and if they obtain a certificate, they sell the product and thus depress its price. Even though lower certification fees would, *ceteris paribus*, attract more high-quality producers, the effect of the entry of low-quality producers is stronger. Thus, some high quality producers are driven from the market, which reduces welfare.

While the previous result assumes no certification costs, the result holds even for the constant marginal cost of each test.

Lemma 3.4 *If there are constant marginal costs for certification smaller than fee f, the welfare optimal equilibrium does not change.*

Proof.   It is easy to show that in the case of constant marginal costs c, the partial derivative of welfare with respect to certification fee f is

$$\frac{\partial W^s}{\partial f} = \frac{c-f}{q^2-2q+2},$$

and thus the welfare is decreasing in f as long as $c < f$, in an honest equilibrium. A similar analysis in the case of a cheating equilibrium shows that welfare is also highest for the highest possible fee, as before. Since with such a fee the welfare in an honest equilibrium and a cheating equilibrium coincide, the overall welfare optimum requires $f = A\frac{q}{2q^2-3q+2}$.

The assumption $c < f$ is reasonable, since this is a necessary condition for certifiers to make a positive profit. Therefore, for a given quality of testing technology, a welfare optimizing regulator would attempt to reduce certification fees up to the point where low-quality producers are indifferent between entering and staying out of the certified market but do not actually enter.

The effect of competition

First, I discuss the results from the previous section in the case where the quality of the testing technology q is given. I focus on the effect that the competition may have on the certification fee.

Corollary 3.2 *If competition between certifiers lowers the fee and does not change the quality of testing, it is beneficial in separating equilibrium, but not in a pooling equilibrium. Moreover, fees determine which equilibrium is viable. If fee f is too low, a separating equilibrium is not viable.*

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[13]Welfare in a pooling equilibrium depends on f non-linearly, but it is easy to show that in the relevant range of f, the welfare is increasing in f.

Even if the competition between certifiers does not have any impact on the quality of the technology q and just lowers the certification fee f, this result shows that "too much" competition reduces fee f below f^* and encourages the entry of cheating producers. Even though high quality producers benefit from a lower fee, the overall welfare effect is not positive—welfare is maximized in the separating equilibrium with the lowest possible fee.

It is possible that for a given number of competing certifiers, both equilibria may be viable. If all certifiers somehow coordinate on a high fee f, for a given quality q, no low-quality producer will enter. Similarly, if certifiers coordinate on a low fee, low-quality producers enter. One equilibrium may dominate the other in terms of welfare or the profits of the certifiers.

Further motivation for introducing competition between certifiers comes from the conjecture that lower fees will result in lower prices of certified products. It is easy to observe that this is true in both equilibria. However, the welfare results show that lower prices do not necessarily imply welfare improvement.

Corollary 3.3 *Price is increasing in fee f in both equilibria. The share of high quality products and the participation of high quality producers are increasing in fee f in a pooling equilibrium, but the participation of low-quality producers is decreasing in f. The participation of high quality producers in a separating equilibrium is decreasing in f.*

This result confirms that the intuition that a lower fee decreases the prices of organic food is correct, but it is incomplete. Lowering certification fees encourages the entry of low-quality producers, which has overall negative consequences on welfare.

Certifiers' revenue

In this section, I show that a monopoly, profit-maximizing certifier does not charge a welfare optimal fee for a given quality of testing technology.[14]

Proposition 3.1 *If the testing technology is costless, the fee that maximizes the total revenue of all certifiers in a pooling equilibrium is*

$$f_p^\Pi = A\frac{1}{2}q\frac{1-q}{(1-2q)(2-3q+2q^2)}, \; for \; q < A\frac{q}{2q^2-3q+2}.$$

For $q \geq A\frac{q}{2q^2-3q+2}$, the constraint $f \leq f^* = A\frac{q}{2q^2-3q+2}$ is binding. The fee that maximizes revenue in separating equilibrium is

$$f_s^\Pi = \frac{1}{2}A(1-q), \; for \; q < 0.37.$$

It easily follows that if the technology is costless, the highest possible revenue in separating equilibrium is always bigger or equal to the revenue of all certifiers in pooling equilibrium.

$$\Pi^p \leq \Pi^s.$$

This result shows that some competition is beneficial. A monopoly certifier that maximizes its revenue (or profit, in the case of costless testing technology) will choose a welfare sub-optimal fee. In the case of a separating equilibrium, the revenue maximizing fee is too large, as expected. In the case of a pooling equilibrium, any fee consistent with a pooling equilibrium is lower than the welfare optimal.

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[14] A welfare maximizing not-for-profit certifier would choose the welfare optimal fee $f^* = \frac{Aq}{2q^2-3q+2}$.

3.4.7   Technology and competition

The previous section discusses the benefits of competition between certifiers if the quality of testing technology is fixed. Because of the incentive structure, I will argue that this represents an optimistic scenario and that one may expect a decrease in the quality of testing technology when the competition becomes more intensive.

I assume that producers are not able to observe the quality of testing technology of individual certifiers. High-quality producers have an incentive to find higher quality certifiers because this reduces the probability of a mistakenly rejected application. However, this is sensitive to the assumptions. For example, if a lower quality of testing simply means less inspection, even high-quality producers might benefit from certification by a certifier of lower quality. If testing technology is asymmetric and high-quality producers always pass the certification test, regardless of the quality that only affects low-quality producers, there are no incentives to learn about the quality of certification. Low-quality producers always have the incentive to find a certifier of lower quality because this increases their chances of passing the test.

Thus, one cannot hope that there would be a significant pressure from high-quality producers to motivate certifiers to improve testing technology, especially if the errors do not harm them. Competition may dilute the incentives of certifiers to invest into the quality of testing technology. For example, if the certifiers have to first invest into testing technology before they compete in prices, then a monopoly certifier would fully internalize the impact of quality on demand for certificates. If there are competing certifiers, the better testing technology of one certifier affects the revenue of all certifiers. More intensive price competition thus may reduce the incentive of a certifier to invest. This argument requires that the overall demand is increasing in the quality of the testing technology. I confirm that this is indeed true in a separating equilibrium. It is also true in the pooling equilibrium for $f = f^*$, as long as the quality of the testing technology is not too low.

Lemma 3.5 *The number of producers applying for a certificate increases when the quality of testing increases*

$$\frac{\partial s_h}{\partial q} = \frac{-1}{(q^2 - 2q + 2)^2}\left(Aq(2 - q) + 2f(1 - q)\right) < 0$$

in a separating equilibrium, but not necessarily in a pooling one. For the highest possible fee, $f^* = A\frac{q}{2q^2 - 3q + 2}$, which is consistent with the pooling equilibrium and the demand is increasing in quality

$$\frac{\partial\left(s_h + s_l\right)}{\partial q}\Big|_{f^*} = \frac{A}{q^2\left(2q^2 - 3q + 2\right)^2}\left(-4q^4 + 4q^3 + 5q^2 - 8q + 2\right).$$

This expression is positive for a sufficiently low fee f.

A more general model of competition between certifiers will need to incorporate possibly different certification fees and different qualities of the testing. This is beyond the scope of the current paper.

3.4.8   Type I and type II errors

Previous analysis suggests that improving the testing technology always improves the welfare. However, it seems possible that such an outcome is a consequence of a particular assumption

about the testing technology—the fact that the probability of rejecting a high-quality producer and awarding a certificate to a low-quality one is the same. Such symmetry in the technology is certainly possible, but not likely. Therefore, I extend the model by distinguishing the probabilities of "type I" and "type II" errors.[15]

I denote the probability that a high-quality producer does not pass the certification tests as q_1. The probability that a low-quality producer passes the test will be denoted by q_2. The analysis is very similar to the previous section, though slightly more technical. All three types (separating, pooling, and no-certification) of equilibria still exist.

Pooling equilibrium

The basic results are very similar to the previous section.

Lemma 3.6 *A pooling equilibrium exists for fee f, which is sufficiently low*

$$f_e^* = A \frac{q_2}{-2q_1 - q_2 + q_1^2 + q_1 q_2 + 2}.$$

It is characterized by

$$
\begin{aligned}
s_l &= \frac{1}{q_2^2} \left(1 - q_1\right)\left(1 - q_1 - q_2\right) \left(A \frac{q_2}{q_1^2 - q_2 - 2q_1 + q_1 q_2 + 2} - f \right); \\
s_h &= \frac{f}{q_2} \left(1 - q_1 - q_2\right); \ and \\
s &= \frac{1}{A} \frac{f}{q_2} \left(q_1^2 - q_2 - 2q_1 + q_1 q_2 + 2\right).
\end{aligned}
$$

Separating equilibrium

In a separating equilibrium, the expected profit of low-quality producers is negative, while a marginal high-quality producer makes zero profit. Thus, probability q_2 determines the viability of separating equilibria, while probability q_1 determines its properties.

Lemma 3.7 *For fee f bigger than f_e^*,*

$$f_e^* = A \frac{q_2}{-2q_1 - q_2 + q_1^2 + q_1 q_2 + 2},$$

but smaller than $A(1 - q_1)$, a separating equilibrium exists, in which the number of applying high-quality producers is

$$s_h = \frac{A(1 - q_1) - f}{\left(1 - q_1\right)^2 + 1}.$$

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[15]If one considers the testing procedure as a test with a null hypothesis of the "product is of high quality", then the probability of type I error is the probability that a high-quality product will be judged to be of low quality (false positive). Type II error is then the probability that a low-quality producer will be judged to be of high quality (false negative).

Welfare

Since I distinguish two types of errors, I may study which error has a bigger influence on welfare. If it is technically possible to reduce q_1 or q_2, such a result tells us where one should focus the bigger investment.

Lemma 3.8 *Welfare in separating equilibrium depends only on q_1.*

$$W_e^s = \frac{1}{2\left(q_1^2 - 2q_1 + 2\right)} \left(A^2 \left(q_1 - 1\right)^2 - f^2\right).$$

Improving the quality of testing technology increases the welfare.

$$\frac{\partial W_e^s}{\partial q_1} = (q_1 - 1)\frac{A^2 + f^2}{\left(q_1^2 - 2q_1 + 2\right)^2} < 0.$$

In the pooling equilibrium, first derivatives of the welfare function are quite technical, and I therefore present those in a special case $q = q_1 = q_2$. The welfare function itself is

Lemma 3.9 *Welfare is increasing in f in the relevant range. Reducing the probability of either error is welfare improving*

$$\frac{\partial W^p}{\partial q_1}|_{q_1=q_2} < 0, \frac{\partial W^p}{\partial q_2}|_{q_1=q_2} < 0;$$

moreover, reducing the type II error improves welfare more than reducing type I error.

$$\frac{\frac{\partial W^p}{\partial q_1}|_{q_1=q_2}}{\frac{\partial W^p}{\partial q_2}|_{q_1=q_2}} \leq 1,$$

for any $f \leq f^* = A\frac{q}{2q^2 - 3q + 2}, q < 0.5$.

These results assume that the testing technology is costless and suggest that if the marginal improvement of the testing technology is equally costly if $q_1 = q_2$, then it is welfare optimal to reduce q_2 instead of q_1, in the pooling equilibrium. In a separating equilibria, q_2 only co-determines whether separating equilibrium is viable. Still, it might be more beneficial to reduce q_2, which allows separating equilibrium for the lower fee f.

Lemma 3.10 *If high-quality producers always pass the test ($q_1 = 0$), then the marginal effect on welfare from an increase in q_2 is bigger than q_1 if $\frac{A}{f}$ is high and q_2 is small.*[16]

If $\frac{A}{f}$ is high, the value of high-quality products is high relative to the certification fees. Thus, not certifying high-quality producers is more harmful than erroneously certifying low-quality ones. Also, if the probability of error for low-quality producers (q_2) is already high, a further marginal increase has a lower impact than the same marginal change in q_1.

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[16]Note that increasing q_i means that the technology gets worse as q_i denotes the probability of the error.

Quality of testing and the type of equilibria

The borderline fee f_e^* that separates the pooling and separating equilibria depends on both q_1 and q_2 :

$$f_e^* = A \frac{q_2}{-2q_1 - q_2 + q_1^2 + q_1 q_2 + 2}.$$

Lemma 3.11 *Improving technology (lowering q_1 or q_2) lowers the borderline fee f_e^*. Moreover, lowering q_2 always reduces the fee f^* more.*

This results show that reducing the type II error (q_2) thus reduces the optimal fee f_e^* more than reducing the type I error.

Profits and quality of technology

Let's analyze the incentives that the certifiers' industry has for investment into testing technology. Revenues of certifiers in separating equilibria are

$$
\begin{aligned}
\Pi^h &= f \frac{A(1 - q_1) - f}{(1 - q_1)^2 + 1} \\
\frac{\partial \Pi^h}{\partial q_1} &= \frac{f}{\left(q_1^2 - 2q_1 + 2\right)^2} \left(-2f(1 - q_1) - Aq_1(2 - q_1)\right) < 0.
\end{aligned}
$$

So certifiers have some incentives to invest into the testing technology, although it is not clear whether they are sufficient.

In a pooling equilibrium, the situation is even less clear.

Lemma 3.12 *Improving testing technology in a pooling equilibrium increases the total profit of certifiers only if the technology is already sufficiently good and certification fees are high enough. For example, at fee f_e^*, any improvement in the testing technology increases the profit of the certifiers for $q < q^{**}$.*

These results suggest that a monopoly certifier would have some positive incentives to invest into testing technology. Competition between certifiers is likely to dilute these incentives as there are positive externalities from investment that cannot be fully internalized.

3.5 Conclusion

This paper studies the adverse selection of low-quality producers in imperfect certification. The previous literature (Strausz, 2005) shows that high fees are required to keep a certifier honest. On top of that, I show that high certification fees also discourage the entry of low-quality producers. In the case of imperfect testing technology, this improves the reliability of the certificate and is in fact welfare improving.

I applied this result in discussing the extent to which competition between certifiers lowering certification fees is optimal. I show that a monopoly certifier chooses a too-high certification fee, but achieves separation. Introducing too many competing certifiers may lower the certification fee below the minimal level consistent with the welfare optimal result and thus be harmful.

I also extend the model to allow for the different probability of type *I* and type *II* errors. I show that reducing any type of error is welfare improving. In an equilibrium, where some low-quality producers apply for a certificate, reducing the probability that such producers would succeed in certification increases the welfare more than reducing the probability that a high-quality producer will fail the certification process. Intuition for this result comes from the fact that not admitting a high-quality producer harms marginal consumers, who have the lowest valuation of organic food, but admitting low quality producers harms the average consumer, which translates into a lower price of certified products and thus harms other producers. In a separating equilibrium, reducing the type *II* error reduces the minimal fee consistent with separation more than reducing the type *I* error does, but this does not have a direct effect on welfare. I also show that the overall revenues of certifiers are decreasing in the type *I* error in a separating equilibrium, which suggests that certifiers have *some* incentives to improve the testing technology. Even though I do not model the competition between certifiers explicitly, I argue that competition reduces these incentives and thus may lead to a lower investment into testing technology.[17]

The main drawback of this analysis comes from the lack of an explicit model of competition both in prices and quality of testing. While I argue that simply to lower the fee reduces the viability of a separating equilibrium, it is likely that competition also reduces the incentives to invest into testing technology and thus leads to lower quality. This would have two negative effects. The first is similar to a reduction in fee f, and impacts the viability of the separating equilibrium. The other impact is direct—I have shown that welfare is affected negatively if the quality of testing technology decreases.

Another limitation of this analysis comes from the fact that I model quality q and certification fee f as uniform across certifiers. It is not trivial to see how producers would behave in an environment in which they can choose from a menu of certifiers with different testing technologies and different fees. Moreover, it is not clear how the certifiers should choose the quality of the testing technology and price their services.

I have also assumed that all producers applying for a certificate pay the same certification fee f. Other assumptions are clearly possible. For example, producers that successfully obtain a certificate may be granted a partial refund of the certification fee. This would increase the payoff for both high- and low-quality producers. Because of the higher probability of success of high-quality producers, the effect would be stronger for them than for low-quality producers. The region of the separating equilibria would thus be larger. Depending on the size of the refund, the region of no viable certification would shrink. One might also consider a fine for unsuccessful producers, which would be very similar to the partial refund of the certification fee f.

Finally, I have assumed commitment to a given quality of testing technology q. Given the structure of, for example, organic certification, it is clear that to sustain a low probability of error and thus a low pass-rate for low quality (non-organic) producers, some supervision of the certifiers must be in place. The current requirements on certifiers mostly focus on their qualification, but very little is known about the actual supervision. A deeper understanding of how supervision should work and how much is required will help us to understand more issues of competition between certifiers. Since certifier profits are likely to increase when the

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[17]The intuition is clear. If each certifier has a smaller market share, improving the technology benefits not only him, but other certifiers as well. Since he cannot internalize these benefits as a single monopoly certifier would, one can expect lower investment in equilibrium when more competitors are present.

competition intensifies, the results of Strausz (2005) suggest that it may be harder to sustain honesty certification.

3.6 Appendix

Proof of Lemma 3.1. It is trivial to verify that equations (3.1-3.4) have a solution (3.5-3.8). The upper bound on fee f^* comes from the condition that a non-negative number of low-quality producers applies for a certificate

$$\frac{(1-2q)(1-q)}{q^2(2-3q+2q^2)}\left(Aq - f(2-3q+2q^2)\right) \geq 0 \iff f \leq \frac{Aq}{2-3q+2q^2}.$$

For a boundary value of fee $f^* = \frac{Aq}{2-3q+2q^2}$, no low-quality producers apply for a certificate and the expected value of doing so is zero. For higher fees, the expected value of an application is negative for low-quality producers.

Proof of Lemma 3.2. In a separating equilibrium, it has to be true that no low-quality producer applies for a certificate. This happens when the expected value of doing so is negative $(pq - f < 0)$. Then, there are no low-quality producers having a certificate $(s = 1)$. The equilibrium conditions then become simply (3.9-3.10). The value of fee f is constrained by the condition $pq - f < 0$. The other condition in equilibrium guarantees that in a separating equilibrium, high-quality producers prefer to apply for a certificate. If $f = p = A(1 - q)$, then only the high-quality producer will apply for a certificate since his production costs are zero, certification costs and expected revenue are equal to $A(1 - q)$. This clearly describes the extreme value of f. For any fee higher than $A(1 - q)$, no certification can take place in equilibrium.

Proof of Lemma 3.3. First, let's derive the function of total welfare. Since both the price of goods and the price of certification represent a transfer, I can compute the welfare as the difference between consumers' utility and production costs:

$$W = \int_{\frac{p}{s}}^{A} sx\,dx - \int_{0}^{s_h} x\,dx = \frac{1}{2}(sA^2 - \frac{p^2}{s} - s_h^2).$$

The welfare function in a separating and pooling equilibrium can be easily derived by plugging in the equilibrium values of the relevant variables (s, p, s_h).

It is straightforward to compute the derivative of both welfare functions (equations 3.11, 3.12).

$$\frac{\partial W^s}{\partial f} = -\frac{f}{q^2 - 2q + 2} \leq 0;$$
$$\frac{\partial W^p}{\partial f} = -\frac{1}{2q^2}\frac{1-2q}{2q^2 - 3q + 2}\left(Aq(6q - 5q^2 + 2q^3 - 3) + f(4 + 16q^2 - 8q^3 - 14q)\right).$$

The sign $\frac{\partial W^p}{\partial f}$ is positive if

$$f \leq Aq\frac{-6q + 5q^2 - 2q^3 + 3}{4 + 16q^2 - 8q^3 - 14q}.$$

Since in a pooling equilibrium for any fee f such that

$$f < f^* = \frac{Aq}{2q^2 - 3q + 2} \le Aq\frac{-6q + 5q^2 - 2q^3 + 3}{4 + 16q^2 - 8q^3 - 14q},$$

the welfare in a pooling equilibrium is increasing in f.

One can easily verify:

$$\frac{\partial W^s}{\partial q} = \left(A^2 + f^2\right)\frac{q - 1}{(q^2 - 2q + 2)^2} < 0;$$

$$\frac{\partial W^p}{\partial q} = \frac{f}{q^3\left(2q^2 - 3q + 2\right)^2}\left(fX + AqY\right)) < 0, \text{ and}$$

$$X = 4 + 41q^2 - 46q^3 + 28q^4 - 8q^5 - 20q,$$

$$Y = 9q - 10q^2 + 13q^4 - 12q^5 + 4q^6 - 3.$$

The expression $\frac{\partial W^p}{\partial q}$ is negative if

$$f < Aq\frac{(-9q + 10q^2 - 13q^4 + 12q^5 - 4q^6 + 3)}{(4 + 41q^2 - 46q^3 + 28q^4 - 8q^5 - 20q)}.$$

As before, it holds that

$$f^* = \frac{Aq}{2q^2 - 3q + 2} \le Aq\frac{(-9q + 10q^2 - 13q^4 + 12q^5 - 4q^6 + 3)}{(4 + 41q^2 - 46q^3 + 28q^4 - 8q^5 - 20q)},$$

and thus welfare is decreasing in the probability of error q (or increasing in the quality of testing technology $1 - q$) in the relevant range of fees.

Proof of Lemma 3.4. If each test costs the certifier c, then the welfare function has to be modified

$$W = \frac{1}{2}(sA^2 - \frac{p^2}{s} - s_h^2) - c(s_l + s_h).$$

In a separating equilibrium, this becomes

$$W^s = \frac{1}{2}\frac{A(1 - q) - f}{q^2 - 2q + 2}\left(A(1 - q) - 2c + f\right),$$

$$\frac{\partial W^s}{\partial f} = \frac{c - f}{q^2 - 2q + 2} < 0.$$

The expression for W^p is technical but easy to obtain. Its derivative with respect to the fee is

$$\frac{\partial W^p}{\partial f} = \frac{1}{2q^2}\frac{1 - 2q}{2q^2 - 3q + 2}\left((c - f)(4 + 16q^2 - 8q^3 - 14q) + Aq(3 - 6q + 5q^2 - 2q^3)\right),$$

which is positive because

$$Aq\frac{(3 - 6q + 5q^2 - 2q^3)}{4 + 16q^2 - 8q^3 - 14q} > Aq\frac{1}{2q^2 - 3q + 2} > f^* > f - c.$$

Thus, the welfare optimum does not change as long as the constant marginal costs of testing are smaller than the fee f.

Proof of Proposition 3.1. The proof of this proposition is straightforward. Let's compute the total revenues of all certifiers, or their profits in the case of costless testing technology in a separating and pooling equilibria:

$$\Pi^s = fs_h = f\frac{A(1-q)-f}{(1-q)^2+1};$$

$$\Pi^p = f(s_l + s_h) = f\frac{2q-1}{2q^4-3q^3+2q^2}\left(2f+Aq^2+8fq^2-4fq^3-Aq-7fq\right).$$

Taking a partial derivative with respect to f gives the first order conditions

$$\frac{\partial\Pi^s}{\partial f} = -\frac{2f-A+Aq}{q^2-2q+2}, \text{ and}$$

$$\frac{\partial\Pi^p}{\partial f} = \frac{1}{q^2}\frac{2q-1}{2q^2-3q+2}\left(4f+Aq^2+16fq^2-8fq^3-Aq-14fq\right).$$

The maximum is reached at $f_s^{\Pi} = \frac{1}{2}A(1-q)$ in a separating equilibrium and

$$f_p^{\Pi} = \frac{1}{2}\frac{Aq(1-q)}{(1-2q)(2-3q+2q^2)}.$$

Note that f_p^{Π} is constrained from above by the condition $f \leq f^* = A\frac{q}{2q^2-3q+2}$. This constraint is binding from $q = \frac{1}{3}$. Similarly, f_s^{Π} is bounded from below by the same expression:

$$\frac{1}{2}(1-q) = \frac{q}{2q^2-3q+2}$$

for $q > q^* = 0.369$. The profit functions are then

$$\Pi_{\max}^s = \frac{1}{4}A^2\frac{(q-1)^2}{q^2-2q+2},$$

$$\Pi_{\max}^p = A^2\frac{(q-1)^2}{16q^4-48q^3+68q^2-48q+16}.$$

It is easy to verify that the maximal profit in the separating equilibrium is higher than in the pooling up to q^*.

$$\frac{(q-1)^2}{16q^4-48q^3+68q^2-48q+16} \leq \frac{1}{4}\frac{(q-1)^2}{q^2-2q+2} \text{ for } q \leq q^a st$$

For $q \geq q^*$, the profits coincide.[18]

Proof of Lemma 3.5. The behavior of the demand for certification in separating equilibrium is simply a derivative of the number of certified high-quality producers. Computing the derivative of the number of high- and low-quality producers in a pooling equilibrium, one gets

$$\frac{\partial\left(s_h+s_l\right)}{\partial q} = -\frac{1}{q^3\left(2q^2-3q+2\right)^2}\left(Aq(11q^2-6q-12q^3+\right.$$

---

[18]Note that formally, one should show that the expression for profits obtained here is indeed maximum. This requires a verification that the second order condition with respect to f is negative in the relevant range, which is rather easy to verify.

$$+2 + 4q^4) + f(-8 - 82q^2 + 92q^3 - 56q^4 + 16q^5 + 40q)).$$

For the borderline fee, $f = Aq\frac{1}{2q^2-3q+2}$, this expression is

$$\frac{\partial (s_h + s_l)}{\partial q} = \frac{A}{q^2 (2q^2 - 3q + 2)^2} \left(-4q^4 + 4q^3 + 5q^2 - 8q + 2\right), \text{ and}$$

is positive for $q < 0.33$. The demand is thus decreasing in quality up to this point.

Proof of Lemma 3.6. I state the equilibrium equations. Solving them is standard. The participation decision of high-quality producers depends on the probability that they will fail the certification test

$$(1 - q_1)p - f - s_h = 0.$$

The second constraint requires zero profit for low-quality producers, depending on the probability that a low-quality producer will succeed in the test

$$pq_2 - f = 0.$$

The definition of the quality of the certificate (the probability that a product with a certificate is in fact of high-quality), depending on the probabilities of mistakes q_1 and q_2 is

$$s = \frac{(1 - q_1)s_h}{(1 - q_1)s_h + q_2 s_l}.$$

Finally, market equilibrium requires

$$A - \frac{p}{s} = (1 - q_1)s_h + q_2 s_l.$$

Proof of Lemma 3.7. Similar to the proof of Lemma 3.2, replace q with q_1 except for the definition of f^* from the previous Lemma.

Proofs of Lemma 3.8 and 3.9. The proof is very similar to the proof of Lemma 3.3 and 3.4 and requires only trivial algebraic manipulations.

Proof of Lemma 3.10. Welfare in a pooling equilibrium is

$$W_e^p = \frac{1}{2} \frac{f}{q_2^2} \left(A \frac{q_2 (1 - q_1)(1 - q_1 - q_2)}{q_1^2 - q_2 - 2q_1 + q_1 q_2 + 2} \left(q_1^2 - q_2 - 2q_1 + q_1 q_2 + 3\right) - f (1 - q_1 - q_2)^2 \right).$$

If we compute the partial derivatives with respect to q_1 and q_2 and plug in $q_1 = 0$, we get the following expressions

$$\frac{\partial W_e^p}{\partial q_1}|_{q_1=0} = -\frac{1}{2} \frac{f}{q_2^2 (2 - q_2)} \left(-4f + 5Aq_2 + 6fq_2 - 4Aq_2^2 + Aq_2^3 - 2fq_2^2\right); \text{ and}$$

$$\frac{\partial W_e^p}{\partial q_2}|_{q_1=0} = -\frac{f}{q_2^3 (-q_2 + 2)^2} \left(-4f + 3Aq_2 + 8fq_2 - 3Aq_2^2 + Aq_2^3 - 5fq_2^2 + fq_2^3\right).$$

If we evaluate the ratio of the first $\left(\frac{\partial W_e^p}{\partial q_1}\right)$ and the second $\left(\frac{\partial W_e^p}{\partial q_2}\right)$ expression, we get

$$\frac{\frac{\partial W_e^p}{\partial q_1}|_{q_1=0}}{\frac{\partial W_e^p}{\partial q_2}|_{q_1=0}} = -\frac{1}{2} q_2 (q_2 - 2) \frac{5Aq_2 - 4f + 6fq_2 - 4Aq_2^2 + Aq_2^3 - 2fq_2^2}{3Aq_2 - 4f + 8fq_2 - 3Aq_2^2 + Aq_2^3 - 5fq_2^2 + fq_2^3}.$$

For sufficiently large[19] $\frac{A}{f}$ and small q_2, the denominator is positive and thus we can write

$$\frac{\partial W_e^p}{\partial q_1}|_{q_1=0} \leq \frac{\partial W_e^p}{\partial q_2}|_{q_1=0} \iff$$

$$-\frac{1}{2}(q_2-1)^2 \left(6Aq_2 - 8f + 8fq_2 - 4Aq_2^2 + Aq_2^3 - 2fq_2^2\right) \leq 0.$$

This condition is equivalent to the condition

$$\frac{A}{f} \geq \frac{8 - 8q_2 + 2q_2^2}{6q_2 - 4q_2^2 + q_2^3}.$$

or again, that the q_2 is small and $\frac{A}{f}$ is large, as required in the theorem. Note that this condition is more strict than the condition from the previous footnote.

Proof of Lemma 3.11 and 3.12. The proof of these lemmas is straightforward. For Lemma 3.12, use $q^{**} = 0.28$.

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[19]It is easy to derive the precise requirement:

$$\frac{A}{f} > \frac{4 - 8q_2 + 5q_2^2 - q_2^3}{q_2\left(-3q_2 + q_2^2 + 3\right)}.$$

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