Incentives for Voluntary Practices, Fraud, and Certification*

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Abstract

We analyze the strategic decision of firms to voluntarily provide high quality on a credence attribute of a product in settings where there is scope for fraud that can be alleviated through third-party certification. Equilibrium outcomes crucially depend on endogenous consumers' beliefs about the credibility of firms' uncertified claims. We find that fraud can only arise under intermediate production costs for high quality relative to fraud costs. Thus, fraud does not emerge with deterrent fraud costs, or when fraud is so cheap that consumers do not trust firms' claims at all. Moreover, increasing certification costs can broaden the range of parameter values for which firms commit fraud. In regards to the choice of voluntary practices, we show that decreases in the costs of high quality do not necessarily entail increased voluntary investments in high quality production or certification. These novel results are robust to different market structures, and question the general desirability of public subsidies for promoting voluntary practices.

Key words: asymmetric information, credence goods, certification, fraud.
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1. Introduction

Problems of asymmetric information about product quality are pervasive in economic markets. The attributes that define high quality are often times credence goods, which are difficult to judge even after purchase (Darby and Karni, 1973; Dulleck and Kerschbamer, 2006). Voluntary investments by firms to produce quality products above regulatory standards have become a mainstream business activity (Kitzmueller and Shimshack, 2012). These include characteristics of production, such as employment discrimination, "fair trade", and human rights (Feddersen and Gilligan, 2001; Baksi and Bose, 2007), long-term health consequences of products (Glaeser and Ujhelyi, 2010), or environmental aspects of products that consumers cannot observe directly, such as organic products, "Dolphin safe" tuna or genetically modified organisms, among others (Baksi and Bose, 2007; Harbaugh, Maxwell and Roussillon, 2011).

Given that the extent of over-compliance for products including these attributes is difficult to assess even after purchase, misleading marketing (fraud) becomes an option (Darby and Karni, 1973; Glaeser and Ujhelyi, 2010; Lyon and Maxwell, 2011). This potential for fraud might question firms' credibility among consumers, and makes certification attractive to guarantee responsible production.[1] In fact, the use of certification is widespread: more than one third of large firms have voluntary external certifications for social and environmental standards (Kitzmueller and Shimshack, 2012).

Interestingly, still many firms base their communication to the public on news releases and marketing campaigns without third-party validation of the claims they make on the quality attributes of their products. This is the case despite scandals for fraudulent marketing among non-certified firms are not rare. Recurrent examples are the use of

[1] Some examples of famous voluntary certification programs are the set of ISO standards or the Global Reporting Initiative (GRI).

specific chemicals on products marketed as "safe and nontoxic" (the scandals around Jessica Alba's the Honest Company being one recent example[2]), abuses of labor conditions for firms with public ethical standards of production (the textile industry being often affected[3]), or the advertisement as "sustainable energy sources" of projects with strong environmental impacts (such as the misleading branding of Shell's oil production in Alberta's tar sands as "sustainable"[4]). The fact that firms continue to signal the credence qualities of their products without certification suggests that such claims have some information content for consumers that are worth the marketing investments.

In sum, the coexistence of conventional production, voluntary provision of higher quality, fraud, and voluntary certification is present in many industries. To our knowledge, the combination of these issues has not been explored in the existing theoretical literature up to date (see the literature review in Section 2). The focus of our study is on voluntary provision and signaling of credence qualities in such contexts. The analysis revolves around whether or not consumers can trust voluntary information provided by firms on the credence quality, and how this affects the choice of voluntary practices and signaling. Thus, this study relates to the literature addressing the extent to which firms voluntarily disclose information in settings where consumers' *endogenous* beliefs on product quality can be updated through signaling or auditing. The main contribution of this study is that we tackle fraud in uncertified production of high quality and we allow, but do not impose, firms to certify their products.

We start by considering a baseline model where a single firm can produce using one out of two technologies, producing a standard (or low quality) version of a product

[2] The Washington Post, March 10 2016 " Laundry Detergent From Jessica Alba's Honest Co. Contains Ingredient It Pledged to Avoid".
[3] The Guardian, October 28 2007 "Child sweatshop shame threatens Gap's ethical image".
[4] The Guardian, August 13 2008 "Shell rapped by ASA for "greenwash" advert".

or a high quality version. All consumers prefer the high- over the low-quality version of the product for the same price.[5] We assume that product quality is a credence good not directly observable by the consumers.[6] As a result, producers can commit fraud about product quality. The firm producing the low quality version can truthfully market its product as low quality or can fraudulently market is as high quality. Despite consumers cannot assess product quality they form endogenous beliefs about the likelihood of honest firm behavior. In addition, the firm can provide (or not) third-party validation through certification if it produces high quality, and markets it accordingly. We later extend this baseline model to allow for oligopolistic competition.

We provide novel results with regards to the likelihood of fraud, investments in high-quality production, and the use of certification. First, regarding the likelihood of fraud, we show that fraud does not emerge for low costs of fraud relative to the costs of high quality production. This result contradicts the standard literature on regulatory enforcement (see for example Becker, 1968 for a seminal reference), which predicts that firms would commit fraud in that case. In our setting, the firm is obviously tempted to cheat, but it anticipates that by doing so consumers will (consistently) believe that it is

[5] Khanna (2001), Lyon and Maxwell (2008), Portney (2008) and Kitzmueller and Shimshack (2012) present excellent reviews of the literature on motivations of firms to undertake voluntary investments beyond regulatory standards. In addition to the demand-driven efforts, which is the focus of this study, these papers include other motivations, such as incentives in employment contracts, "warm glow" preferences, social norms, private (NGOs) and public politics.

[6] Dulleck et al. (2011) characterize the credence good literature in two separate streams. The first considers that consumers do not know what they need, but they observe the utility from what they get. The subjects of interest in this case are markets, such as those for doctors and mechanics, where undertreatment, overtreatment and overcharging are crucial forms of fraud (e.g. Emons, 1997). Dulleck and Kerschbamer (2006) present an excellent review of this literature jointly with a model of credence goods that provides an unifying framework for the different market institutions and information structures on efficiency. The second stream of the credence goods literature is based on the definition that credence goods have qualities that are difficult to judge even after purchase. In this case, consumers know what they want but observe neither what they get nor the utility derived from what they get. In this paper, we adhere to the second definition.

committing fraud. Therefore, consumers will not assign any additional value to this claim, and, hence, the firm will not have any incentive to commit fraud.

Second, increasing certification costs can broaden the range of parameter values for which firms commit fraud. This contrasts with results from previous studies addressing the potential for fraud in the use of labels. For example, Hamilton and Zilberman (2006) show that raising certification costs can reduce or even eliminate fraud in high quality production. The main difference between their study and ours is that their analysis does not allow for fraud in uncertified production, although it is more flexible in the information content of certifications, which can be fraudulently obtained by low-quality products. In our case, certification is perfectly accurate but voluntary, which gives room for fraud in uncertified production. This difference in focus results in a sharp different conclusion.

Two additional interrelated results refer to the likelihood of the use of certification and high-quality production. In particular, we find that decreases in the costs of producing high quality do not necessarily entail increased investments in high-quality or certification. The reason is that a decrease in the cost of producing high quality may increase consumers´ beliefs on the truthfulness of uncertified claims. This in turn may entail an increase in consumers´ (expected) willingness to pay for uncertified high quality. Thus, offering the certified version may become less attractive, since consumers´ willingness to pay for this option remains unchanged. This countervailing result in the likelihood of certification has important implications in the likelihood of investments in (true) high quality production, which result in novel policy implications on the relative performance of certification subsidies as compared to subsidies to high quality production.

We organize the remaining of the paper as follows. In the next section, we stress our contribution to the related literature. In Section 3, we present the baseline model. In Sections 4 and 5, we respectively derive and discuss the results. In section 6, we provide, for the interested reader, a robustness analysis under oligopolistic competition. We conclude in Section 7.

2. Contribution to the literature

The general problem of voluntary disclosure of information on product quality has received attention in the literature for long (see Dranove and Jin, 2010 for a review). However, the focus has been restricted to contexts where sellers do not lie about product quality, for example given the presence of deterrent antifraud laws. Sellers, though, can be vague in their claims about product quality, and consumers interpret any vague claim as revealing that the true quality is at the lowest level consistent with the claims being truthful. For example, Grossman and Hart (1980) and Grossman (1981) consider a monopolist who is exogenously informed about product quality and decides whether to reveal this information to consumers, and Matthews and Postlewaite (1985) impose that the seller must first decide whether to acquire (at no cost) information on product quality. The main result of all these studies is that even without laws mandating full disclosure, the seller reveals all relevant information in equilibrium.[7] Okuno-Fujiwara et al (1990) emphasize how restrictive the conditions which guarantee information revelation are, once acknowledging that only certifiably truthful statements will be credible. Similarly, Fishman and Hagerty (1990) show that rules limiting discretion (requiring the informed

[7] In a more general setting, Shavell (1994) considers that either sellers or buyers might acquire private information over the good that they can later choose to share. This results in socially excessive incentives to acquire information, and in turn mandatory disclosure is socially desirable for sellers but not for buyers.

party to disclose a signal from a prespecified subset of available signals) may lead to more informative disclosures.

The results of these studies critically depend on the possibility of parties to convey information credibly. Information is verifiable, and in contexts where sellers cannot lie, the only issue is how much of the truth they will decide to tell. Thus, these studies do not tackle how the potential for fraudulent marketing might influence sellers' decisions to voluntarily disclose information on product quality. In addition, in these studies quality types are assumed to be exogenous and independent. However, in a broad range of production activities, product quality is an endogenous decision that might come influenced by the quality choices of competitors. In fact, the different varieties of a product characterized by price-quality combinations are to some extent substitutes in consumption.

The theoretical literature on over compliance considers contexts of endogenous and interdependent types. This literature has separately addressed quality investment driven by a desire of firms to self-differentiate and investments in certification to tackle the problem of asymmetric information between consumers and producers. Our paper provides a bridge between the two strands of the literature.

The literature focusing on incentives for self-differentiation addresses the implications of production technology choices in markets where (at least a subset of) consumers value and can observe the quality of products (e.g. Arora and Gangopadhyay, 1995; Conrad, 2005). Choosing technology acts as product positioning, opening up for differentiation strategies for firms (Kitzmueller and Shimshack, 2012). Substantial research efforts in these settings have addressed the interaction between the institutional context (taxes, subsidies and standards) with differentiation investments (Moraga-

González and Padrón-Fumero, 2002; Bansal and Gangopadhyay, 2003). More generally, previous theoretical contributions claim that over compliance in socially desirable attributes can be understood as contexts where consumers can choose to consume impure public goods that generate both private and public features (Kotchen, 2005, 2006, 2013). However, this literature has abstracted from the credence good nature of voluntary quality investments by firms.

From a different perspective, the literature focusing on certification addresses the asymmetric information problem characterizing the credence good nature of some voluntary efforts by firms (e.g. Sedjo and Swallow, 2002; Amacher, Koskela and Ollikainen, 2004; Harbaugh, Maxwell and Roussillon, 2011). A central aspect of this literature is that firms producing conventional products have incentives to pretend to be of high quality (cheat) and profit from consumers' higher willingness to pay, while saving the associated production costs. These studies assume that in the absence of credible information disclosure mechanisms, consumers will not believe any of the firms' claims about the quality of products, requiring the use of certification to convey any information on product quality. Consequently, available strategies for firms are restricted to invest in high quality coupled with certification or use conventional production.[8]

In the certification literature, substantial research efforts have tackled the interrelation between voluntary certification and the institutional context (Feddersen and Gilligan, 2001; Heyes and Maxwell, 2004; Baron, 2011; Glachant and Moineville, 2012). Some studies address the incentives for firms to deliberately misuse the labeling process to fraudulently sell their products as high quality (Hamilton and Zilberman, 2006; Baksi

[8] An exception is Baksi, Bose and Xiang (2016), who consider the coexistence of third party certification, self-labels (uncertified) and conventional production, but take consumers' beliefs on the information content of self-labels to be exogenously defined by a parameter common to all consumers.

and Bose, 2007; Glachant and Moineville, 2012). Remarkably though, none of these previous studies allow firms to choose between uncertified and certified high quality investments, as the present study does. This is relevant because as Kitzmueller and Shimshack (2012) argue, the notion of "voluntary behavior" is critical in the conception of corporate social responsibility. The literature on certification has explored additionally the implications of imperfect certification processes in which errors can occur (Mason, 2006) and in contexts where these errors are noisy (Mason, 2011). Then, as well, consumers' uncertainty about certification standards affect managerial decisions to certify products (Harbaugh, Maxwell and Roussillon, 2011).

3. The base model

3.1. The firm

A monopolist can produce either a low or a high quality version of a commodity. Low quality represents the standard version of the product, in accordance with all relevant regulations (for example, safety standards, working conditions, health issues or environmental standards). High quality stands for a version entailing superior performance in at least one dimension valued by consumers, therefore over-complying with regulatory mandates.

The product at hand presents credence good attributes and, therefore, it is impossible for consumers to distinguish between low and high quality even after purchase. This introduces the possibility that the firm markets its product to consumers fraudulently. If the firm produces the low quality version, it can choose to either truthfully market the product as low quality (strategy *L*) or commit fraud and falsely present the product to consumers as high quality, aiming to capture additional consumer surplus

(fraudulent strategy F). If the firm produces the high quality version truthfully, it can additionally opt to certify it. Thus, in this case the firm can choose to market the product as uncertified high quality (strategy H) or as certified high quality (strategy C).[9]

Firm's profits depend on the selected strategy as follows:

$$\pi_i = q_i(p_i - t_i), \qquad i = L, F, H, C,$$

where q_i is the total amount of the good produced and sold in case the firm follows strategy i, p_i is the per-unit price and t_i is the total per-unit cost of that strategy. Without loss of generality, we assume that the per-unit cost of strategy L is zero, i.e., $t_L = 0$. For strategy F, $t_F = f$, where $f \geq 0$ is the per-unit expected cost of committing fraud. For strategy H, $t_H = h$, where $h > 0$ is the per-unit cost of producing high quality. Finally, for strategy C, $t_C = h + c$, where, $c > 0$ is the per-unit certification cost to be added to the cost of producing high quality.[10] We assume that the certification process is perfectly accurate.[11]

There are several reasons why firms may face potential costs associated to fraudulent marketing. One possibility is monitoring and enforcement of antifraud regulations by the Government, such as those regarding false advertising, perjury and warranties of fitness. This could result in fines for fraud or other non-monetary costs

[9] Throughout the paper we concentrate on the performance of the firm and, therefore, we assume a passive role for the certifier(s), that is, we do not explicitly model the optimal setting of certification fees. For example, (Farhi, Lerner and Tirole, 2013) study strategic transparency of certifiers, Fisher and Lyon (2014) analyze certifiers´ behavior in both autarky and competitive settings, Harbaugh, Maxwell and Roussillon (2011) address concerns related to increasing number of alternative labels, and Heyes and Martin (forthcoming) study labeling by competing NGOs. Dranove and Jin (2010) offer an excellent review of older literature.

[10] We model certification costs in a similar way as Mason (2011). In many instances, though, certification costs include a fixed component, which is independent of the quantity produced. Our results do not qualitatively change if we consider that alternative assumption.

[11] This is obviously a simplification of reality, but we consider this assumption in order to concentrate on the problem of fraud in uncertified production. For example, Mason (2006) considers the implications of imperfect certification processes in which errors can occur, and Mason (2011) analyzes contexts where these errors are noisy. We also abstract from the strategic misuse of certification (Hamilton and Zilberman, 2006; Baksi and Bose, 2007; Glachant and Moineville, 2012).

associated to worsening relations with the regulator. An alternative derives from the existence of a nonstrategic activist that scrutinizes the market of uncertified products in search for fraud. Boycotts or reduced consumers' trust are potential outcomes in these cases.[12]

We assume that the monopolist has perfect information about all the parameters of the model, including the costs associated to each strategy. The reason for this assumption is presentation simplicity. However, our results qualitatively hold if we alternatively consider that the monopolist is imperfectly informed about its cost parameters, as long as it is better informed than consumers.

3.2. Consumers

The demand is characterized by a mass of consumers that can each purchase at most one unit of the good. We assume all consumers have the same willingness to pay for low quality, denoted as $\underline{\theta}$, and heterogeneous preferences for high quality. All consumers prefer high versus low quality for the same price, and θ_j represents consumer j's additional willingness to pay for high quality, which is uniformly distributed in the interval $[0,1]$.

As noted above, there are four possible strategies available for the firm (L, F, H, C). However, the credence good nature of the product results in consumers only distinguishing among the three possible marketed versions of the product: low quality

[12] Conceiving an expected penalty for fraud derived from an activist that acts according to a specified rule (non-strategic) is inspired in Lyon and Maxwell (2011). In their application, the activist focuses on firms that selectively report good news. In ours, the activist simply punishes firms for bad outcomes. Empirical marketing literature shows that there are indeed settings where firms' investments in voluntary over compliance affect consumers' perceptions about firms' and this in turn affects firms' profits (see for example Sankar Sen and Bhattacharya, 2001; Becker-Olsen, Cudmore and Hill, 2006). Whatever the reason behind the costs of fraudulent behavior, we treat them as a cost per unit of production, in a similar fashion as production or certification costs. Again, including a fixed component would not qualitatively change any result.

(L), uncertified high quality (U, which comprises both strategies F and H) and certified high quality (C).

We assume that consumers face uncertainty about the costs the monopolist faces. For presentation purposes, we particularly assume that consumers know the cost of high quality production, but they do not know the specific value of the fraud costs. Thus, f works as the type of the monopolist, which is private information. Consumers, though, know the probability distribution of the types. We assume $f \in [0, \overline{f}]$, $\overline{f} > 0$, with probability distribution $G(f)$, such that $G(0) = 0$, $G(\overline{f}) = 1$ and $G'(\cdot) \geq 0$.[13] Assuming uncertainty on the cost of fraud is realistic as it depends for example on the probability of being caught, which might include a subjective component on the part of the firms that consumers cannot perfectly assess. An alternative specification with uncertainty on production costs for high quality generates the same results, and qualitatively similar results can be derived if consumers are uncertain in both costs for high quality production and for fraud.

With this information in mind, consumers have *prior* beliefs, denoted as $\alpha \in [0,1]$, about the likelihood that uncertified claims of high quality production are truthful. Consumers have the possibility to update these beliefs through price signals of uncertified claims, p_U, where U embraces both strategies H and F. We denote these *posterior* beliefs as $\alpha(p_U)$. The specific way in which these beliefs are updated is described in Section 4.

3.3. The combined system

[13] The specific shape of the probability distribution is not crucial for our analysis, and then we keep it general. A more general function of the form $f \in [\underline{f}, \overline{f}]$, $0 < \underline{f} < \overline{f}$ would support identical results, being $h > \underline{f}$ the relevant case to consider. Allowing for $h < \underline{f}$ means that even the smallest fraud costs consumers can envision for firms to face result deterrent, and consequently it brings the uninteresting case where fraud can never emerge.

The timing of the model is the following. In the first stage, a monopolist of type f decides the combined production and marketing strategy out of the four available strategies, (L, F, H, C). In the second stage, the monopolist chooses the quantity and the price for the variety chosen in the first stage. In doing so it takes into consideration that consumers form posterior beliefs about the likelihood of purchasing true high quality when confronted with uncertified high quality at a given price p_U. These beliefs affect consumers' (expected) willingness to pay and the associated firm's profits. We solve the game using the concept of perfect Bayesian equilibrium (see Fudenberg and Tirole, 1991). [14]

4. Results

In this section, we study the monopolist's optimal decision. We first derive the characteristics of each possible equilibrium strategy. Then, we derive the conditions for the existence of each equilibrium strategy.

The first possibility is to follow strategy L, that is, to produce low quality and market it as such. Consumers perfectly identify strategy L with low quality, as they can deduce that the firm has no incentive to produce high quality and market it as low quality. The reason is simply that consumers anticipate that if the firm produces high quality it has to incur additional production costs that cannot be covered through the price of the low quality variety. Therefore, consumers' surplus for low quality is the difference between the willingness to pay ($\underline{\theta}$) and the corresponding price (p_L). Since all consumers have the same willingness to pay for low quality ($\underline{\theta}$), the optimal strategy for the

[14] In this equilibrium, the strategies of the players are optimal for given beliefs and strategies of the other players. In turn, beliefs on the equilibrium path are updated from observed actions according to Bayes' rule, while beliefs off the equilibrium path are updated according to Bayes' rule whenever possible.

monopolist is to offer the product to all consumers at the maximum possible price. Thus, $q_L^* = 1$ and $p_L^* = \underline{\theta}$, and since production costs of this variety are zero, associated profits are $\pi_L{}^* = \underline{\theta}$.

Now, we consider strategy C, that is, to produce certified high quality. Perfect credibility with regards to the certification process ensures that consumers perfectly identify strategy C with high quality. Then, consumer j's surplus is the difference between the willingness to pay in this case ($\underline{\theta} + \theta_j$), and the respective price p_C. For a given p_C only consumers with an additional willingness to pay for high quality larger than $p_C - \underline{\theta}$ will purchase the product. Then, $q_C = 1 - p_C + \underline{\theta}$. The monopolist faces both production and certification costs ($h + c$), and the problem of the monopolist is to choose the price that maximizes profits from strategy *C*, $\pi_C = (1 - p_C + \underline{\theta})(p_C - h - c)$, from which we derive $p_C{}^* = \frac{1+h+c+\underline{\theta}}{2}$ and $q_C{}^* = 1 - p_C{}^* + \underline{\theta} = \frac{1-h-c+\underline{\theta}}{2}$ (note that $q_C{}^* < 1$ since $p_C{}^* > \underline{\theta}$). The associated profits in this case are $\pi_C{}^* = \left(\frac{1-h-c+\underline{\theta}}{2}\right)^2$.

Lastly, we consider the version of the product presented to the market as uncertified high quality (*U*), which corresponds to strategies F or H. The monopolist in this case bases its decision to follow strategy F or H exclusively on whether f is smaller or larger than h, opting for the strategy that entails lower costs. Consumers are not able to verify the quality of the product, and fraud costs are private information of the firm. Hence, consumers observe the price set by the monopolist, p_U, and update their prior beliefs α on the probability that the product is truly high quality into their posterior beliefs $\alpha(p_U)$. We assume that this adaptation only takes place if consumers observe a price different than the price a firm truly offering high quality would set, denoted as $p_H{}^*$. Thus, if the firm sets the price $p_U = p_H{}^*$, consumers keep their prior beliefs on the truthfulness of uncertified claims. That is, $\alpha^*(p_U = p_H{}^*) = \alpha$, where $\alpha = prob(U = H) =$

$prob(f \geq h) = 1 - G(h)$. If, on the other hand, the price set by the monopolist is different from ${p_H}^*$, then consumers do not believe the firm´s uncertified claim, and consequently, $\alpha^*(p_U \neq {p_H}^*) = 0$.[15]

With this adaptation of consumers´ beliefs in mind, consider first a monopolist´s type such that $f > h$. Then, the firm prefers strategy H over strategy F, as fraud costs are deterrent. The firm knows that consumers can maintain their prior beliefs on the truthfulness of uncertified claims, α, only if the firm announces its profit maximizing price ${p_H}^*$. Assuming risk neutrality, consumer j's expected surplus for uncertified high quality (U) is the difference between the *expected* willingness to pay ($\alpha(\underline{\theta} + \theta_j) + (1-\alpha)\underline{\theta} = \underline{\theta} + \alpha\theta_j$) and the corresponding price, p_U. Thus, for a given price, p_U, only those consumers with an additional willingness to pay for uncertified high quality larger than $\frac{p_U - \underline{\theta}}{\alpha}$ purchase the product, and then, $q_U = 1 - \frac{p_U - \underline{\theta}}{\alpha}$. The price that maximizes the associated expected profits for truly offering high quality is ${p_H}^* = \frac{\alpha + h + \underline{\theta}}{2}$.[16] Then, ${q_H}^* = 1 - \frac{{p_H}^* - \underline{\theta}}{\alpha} = \frac{\alpha - h + \underline{\theta}}{2\alpha}$ (where ${q_H}^* < 1$), and expected profits are ${\pi_H}^* = \frac{1}{\alpha}\left(\frac{\alpha - h + \underline{\theta}}{2}\right)^2$, where $\alpha = 1 - G(h)$.

If, alternatively, the monopolist´s type is such that $f < h$, it prefers strategy F over H. Having in mind the potential update of consumers´ beliefs, the firm selects ${p_F}^* = {p_H}^*$ (it mimics the monopolistic price of a truthful high quality producer) to

[15]There are many ways under which one can define beliefs, but this particular form satisfies the *intuitive* criterion of Cho and Kreps (1987), which imposes certain conditions on uninformed individuals' out-of-equilibrium beliefs, in the sense that certain types of agents should not be expected to use certain strategies. In our setting, this means that if the price set by the firm is different than the profit maximizing price a firm offering true high quality would set, consumers assign probability zero to that firm actually having produced high quality. Under these circumstances a firm type falsely offering high quality has no choice but setting the monopolistic price of a honest firm type if it wants to (falsely) gain some credibility. The use of the intuitive criterion for defining *admissible* beliefs allows us to uniquely characterize the equilibrium for given parameter values.

[16] The problem in this case is $max_{p_H}\, \pi_H = \left(1 - \frac{p_H - \underline{\theta}}{\alpha}\right)(p_H - h)$.

manipulate consumers so that they keep their prior beliefs, α. Expected profits in this case are $\pi_F{}^* = q_H{}^*(p_H{}^* - f) = \left(\frac{\alpha - h + \underline{\theta}}{2\alpha}\right)\left(\frac{\alpha + h + \underline{\theta} - 2f}{2}\right)$.[17]

The following proposition summarizes the results so far.

Proposition 1. *For given* $(h, c, f, \underline{\theta})$*, the monopolist's equilibrium strategy can be:*

(i) *L such that* $q_L{}^* = 1$, $p_L{}^* = \underline{\theta}$ *and* $\pi_L{}^* = \underline{\theta}$;

(ii) *H such that* $q_H{}^* = \frac{\alpha^* - h + \underline{\theta}}{2\alpha^*} < 1$, $p_H{}^* = \frac{\alpha + h + \underline{\theta}}{2}$ *and* $\pi_H{}^* = \frac{1}{\alpha^*}\left(\frac{\alpha^* - h + \underline{\theta}}{2}\right)^2$;

(iii) *F such that* $q_F{}^* = \frac{\alpha^* - h + \underline{\theta}}{2\alpha^*} < 1$, $p_F{}^* = \frac{\alpha^* + h + \underline{\theta}}{2}$ *and* $\pi_F{}^* = \left(\frac{\alpha^* - h + \underline{\theta}}{2\alpha^*}\right)\left(\frac{\alpha^* + h + \underline{\theta} - 2f}{2}\right)$;

(iv) *C such that* $q_C{}^* = \frac{1 - h - c + \underline{\theta}}{2} < 1$, $p_C{}^* = \frac{1 + h + c + \underline{\theta}}{2}$ *and* $\pi_C{}^* = \left(\frac{1 - h - c + \underline{\theta}}{2}\right)^2$;

with $\alpha^* = \alpha(p_U = p_H{}^*) = \alpha$ and $\alpha^* = \alpha(p_U \neq p_H{}^*) = 0$, where $U = H, F$ and $\alpha = prob(f \geq h) = 1 - G(h)$.

Under strategies *H*, *F* and *C* the equilibrium quantity produced is lower than the overall mass of consumers. In these cases, the associated prices need to account for high quality production and certification costs, and since consumers are heterogeneous with respect to their additional willingness to pay for high quality, some consumer may end out of the market. For strategies *H* and *F* this is the typical "lemons" result (Akerlof, 1970), whereby dishonest dealings tend to drive honest dealings out of the market. There

[17] In sum, the choice of the monopolist with regards to strategies *F* and *H* crucially depends on its type f. Note that there is a continuum of types in the interval $[0, \overline{f}]$, but only two hidden actions embedded in an uncertified claim of high quality, *H* or *F*. Thus, for a threshold type $\tilde{f} = h$ that would be indifferent between the two actions *H* and *F*, α can alternatively describe the proportion of types that strictly prefer *H* over *F*, that is, those such that $f \geq \tilde{f}$.

might be potential buyers for legitimate high quality production offered at the given price p_U, but the presence of fraud reduces consumers' willingness to pay and hampers the legitimate firms producing high quality. Additionally, less than full market coverage also occurs in strategy *C*, where no fraud exists, due to consumers´ heterogeneity regarding their additional willingness to pay for high quality.

We now turn to existence considerations of each equilibrium strategy. Out of the four admissible strategies (L, F, H, C), the monopolist prefers the one with the largest associated profits. It is important to highlight that consumers' beliefs on the trustworthiness of uncertified claims affect the existence conditions of all equilibria through its impact on profits for strategies H and F (see ii and iii in Proposition 1, above). The following proposition presents the conditions for the existence of each equilibrium strategy in the space of combinations of high quality production costs (h) and certification costs (c). Remarkably, the equilibrium strategy is unique for given parameter values.

Proposition 2. *Given a monopolist's type f, the set of parameter values (h, c) that delimits the area where equilibrium C is preferred is non-linear and non-monotone. The preference for equilibria H or F is delimited by $h = f$; and the preference for equilibria F or L is delimited by $h = \hat{h}$, where $\pi_F{}^* = \pi_L{}^*$. As long as $f < \hat{h}$, the monopolist can be fraudulent in equilibrium for $h \in (f, \hat{h})$.*

We explain Proposition 2 with the help of Figure 1. In the horizontal axes we measure the unit cost of producing high quality (h), while in the vertical axes we represent the unit certification cost (c). This figure illustrates the most complete case where all strategies can be equilibrium strategies, depending on the specific values for (h, c).

[INSERT FIGURE 1 ABOUT HERE]

We first comment on the upper part of Figure 1. There, certification costs are large enough such that the certification strategy C is not optimal. The figure shows that the monopolist switches from high quality production (H) to low quality production with fraud (F) to finally low quality production marketed as such to consumers (L) as the unit cost of producing high quality, h, increases.

First, in choosing between producing high quality or producing low quality and commit fraud (strategies H or F), a monopolist of type f exclusively focuses on the relation between h and f. For h such that $h \leq f$, fraud costs are deterrent and strategy H is preferred. For h such that $h > f$, the monopolists' profits are higher when committing fraud. Despite consumers cannot ascertain if they are purchasing H or F, since fraud costs f are only known by the monopolist, they hold beliefs on the monopolist's quality claims. Their expected trustworthiness of the monopolist decreases in h, as they anticipate the monopolist is more prone to fraud for higher production costs. For sufficiently large h, consumers´ beliefs on the truthfulness of uncertified claims α^* decrease up to the point that strategy L is preferred over strategy F. Given the lack of trust on high quality products, the additional willingness becomes small enough so that it does not pay for the monopolist to incur in the costs of fraud.

Now, the monopolist prefers the certification strategy when certification costs are relatively low. Interestingly, the monopolist faces a threshold condition for choosing strategy C that is non-linear and non-monotone in h. The explanation for the non-linearity relies on the specific assumptions about the probability distribution of f. The explanation for the non-monotonicity is more puzzling, but it is key for the results we will derive later on.

The increasing part of the threshold condition for choosing C (see Figure 1) is defined by the implicit relationship between h and c such that profits for strategies C and H are equal (for $h \leq f$), and the implicit relationship such that profits for strategies C and F are equal (for $h > f$). Both implicit relationships depend on consumers' endogenous beliefs. For the extreme case where $h = 0$, consumers can ascertain that fraud costs are deterrent, for any positive value of fraud costs. Consistently, consumers' beliefs of uncertified claims are $\alpha^*(p_U = {p_H}^*) = 1$ and $\alpha^*(p_U \neq {p_H}^*) = 0$. Since consumers completely trust firms' uncertified claims, certification does not provide additional information, while it entails additional certification costs. As a result, strategy C does not arise when $h = 0$.

As h increases, profits associated with strategies H and C decrease, but the reduction of profits for strategy H is larger. For given beliefs, an infinitesimal increase in h implies $\frac{\partial \pi_H}{\partial h} = -\frac{\propto - h + \underline{\underline{\theta}}}{2\alpha} = -q_H^*$ and $\frac{\partial \pi_C}{\partial h} = -\frac{1 - h - c + \underline{\underline{\theta}}}{2} = -q_C^*$. Since ${p_H}^* = \frac{\alpha + h + \underline{\underline{\theta}}}{2}$ and ${p_C}^* = \frac{1 + h + c + \underline{\underline{\theta}}}{2}$, we can easily conclude that ${p_H}^* < {p_C}^*$ and therefore $q_H^* > q_C^*$, which means that for given beliefs the impact on the profits associated with strategy H are larger. Additionally, consumers' trust on the uncertified version decrease as h increases. Given that the impact of a change in beliefs on profits for strategy H is positive, as $\frac{\partial \pi_H}{\partial \propto} = -\frac{1}{\alpha}\left(\frac{\propto - h + \underline{\underline{\theta}}}{2}\right)\left\{\frac{\propto - h + \underline{\underline{\theta}}}{2\alpha} - 1\right\} > 0$ and $\frac{\propto - h + \underline{\underline{\theta}}}{2\alpha} \equiv q_H^* < 1$, an increase in h causes a further decrease in profits associated with strategy H due to the induced change in the beliefs. On the contrary, profits associated with strategy C do not change with consumers' beliefs. In sum, profits associated with strategy H decrease more than those associated with C as h increases, and consequently, for $h \leq f$ the corresponding threshold level of c so that $\pi_H = \pi_C$ increases.

A similar conclusion follows for the threshold relationship between C and F once $h > f$. This threshold condition is implicitly given by ${\pi_F}^* = {\pi_C}^*$. Following a similar procedure, the reduction of profits for strategy F can be proven to be larger than that for strategy C as long as h increases. Again, consumers' beliefs on the truthfulness of uncertified claims decrease in h, and the certification strategy becomes more attractive for larger values of h.

The decreasing part of the threshold condition for choosing C arises for $h \geq \hat{h}$ when profits for strategies C and L are equal. In this case, consumers' beliefs do not play any role, since they do not affect profits associated with C or L. Note that profits associated with strategy L are independent of both h and c. The negative relationship between h and c is mediated by a need to compensate via lower certification costs the increases in the costs of producing the high quality such that both profits are kept equal as h increases.

5. Discussion

In this section, we discuss some intriguing results that derive from all the mathematical analysis presented in the previous section. These results refer to the likelihood of fraud, the likelihood of supplying (true) high quality, and the likelihood of certification. We first provide a statement for each result, and we then offer an intuitive explanation.

Result 1. *It is possible that in equilibrium the monopolist commits fraud on product quality. Fraud cannot arise under extreme values of high quality production or*

fraud costs but only under intermediate costs of fraud relative to high quality production costs.

This result is interesting and somehow counterintuitive from the point of view of the standard literature on regulatory enforcement, which claims that agents violate laws whenever the expected costs of complying are larger than those of non-complying, as in Becker (1968). Translated to our context, the enforcement literature would suggest that fraud can only arise if the (expected) costs of committing fraud (in our case, f) were smaller than the costs of producing genuine high quality (h). As we have seen in the previous section, endogenously considering consumers´ beliefs is critical in the analysis and precludes the emergence of fraud when both $h > f$ and $h > \hat{h}$, that is, when fraud costs are relatively small. This is because consumers anticipate that uncertified products would be fraudulent and are not willing to pay any additional price premium for uncertified production. In this case, the monopolist's strategies become limited to producing the low quality version or truly producing and certifying the high quality version.

Therefore, fraud can only arise when consumers show some but less than complete trust on the monopolist's uncertified claims. Coming back to the examples in the introduction, the combined existence of marketing campaigns where firms present their products as of higher quality in a credence attribute in markets where scandals for misleading marketing are relatively frequent, would be compatible with consumers' trust being positive but less than perfect. For the European Union, surveys on consumers' trust on green products show that this is the case for a large proportion of consumers (Commission, 2009).

Result 2. *When fraud arises, increasing certification costs broadens the range of parameter values for which the monopolist commits fraud.*

The interrelation between fraud, investment in high quality, and certification entails that as certification costs increase (for a firm of a given type f), the range of parameter values of h for which the firm engages in fraudulent marketing is broader. This result differs from the findings of Hamilton and Zilberman (2006) regarding the emergence of fraud in the use of labels. Their analysis does not allow for high quality production to be marketed without certification (and consequently for fraud in uncertified products) but it is more flexible in the information content of certifications, which can be fraudulently obtained by low-quality products. Their results support that certification costs can reduce or eliminate fraud in high quality markets by reducing the marginal return to disguising low and high quality. This difference in focus results in a sharp different conclusion, since our findings suggest that when considering the potential for fraud in uncertified production, increasing certification costs might not alleviate, but rather strengthen the prevalence of fraud.

Next, Result 3 addresses the likelihood of certification:

Result 3*. A decrease in the cost of producing high quality does not necessarily entail that the monopolist is more prone to certification.*

This result is illustrated in Figure 1, and it derives from the non-monotone shape of the delimiting range of parameter values that make strategy C being optimal (see Proposition 2). The result seems counterintuitive, since we would expect that as production cost of high quality h decreases, strategy C becomes cheaper and certification emerges for a larger range of admissible values of c.

The explanation relies on consumers´ trust on the firm's uncertified claims of high quality. As long as the cost of producing high quality decreases, consumers´ willingness to pay for uncertified high quality increases, since consumers' trust increases. Offering the certified version can then be attractive for large enough high quality costs, where consumers´ willingness to pay for the uncertified version is negligible. However, lower high quality production costs are associated with larger willingness to pay for the uncertified version, and everything else equal, a lower preference for the certifying version.

The effects described in Results 1-3 have implications on the overall investments in high-quality production, as defined in result 4.

Result 4. *A decrease in the cost of producing high quality does not necessarily entail that the monopolist is more prone to produce the high quality version.*

Again, this result is counterintuitive, since we would expect the monopolist being more prone to offer high quality as the cost of producing high quality decreases. To illustrate this result, let us fix a value for the unit certification cost (c) in Figure 1, and consider the monopolist´s optimal strategy as the unit cost of high quality production (h) decreases, that is, as we horizontally move from right to left in the figure. Clearly, for very low values of c, the monopolist´s optimal strategy changes from L to C first, and next to H for even lower values of h. That is, as intuition suggests, it switches from low to high quality production as h decreases.

Similarly, for large enough values of c, the monopolist´s optimal strategy moves first from L to F and next to H as h decreases. But interestingly, for intermediate values of c, as h decreases the optimal strategy changes first from L to C, and next it switches to low quality fraudulently marketed F, to finally move to high quality production without

certification H. That is, at some point the monopolist´s optimal strategy switches from high quality (certified) to low quality (with fraud) as h decreases.

The reason for this result can be found in consumers´ equilibrium beliefs associated to the monopolist´s claims of (uncertified) high quality. For given f (the monopolist type), as long as h decreases (movement from right to left) in Figure 1, consumers´ trust of uncertified claims increase. Then, committing fraud becomes more attractive, possibly becoming preferable to offering the certified version. Formally, by keeping on the fraudulent strategy consumers are willing to pay $\alpha^{*}\theta_j$, which increases as h decreases, while by affording the additional cost of certifying the high quality version, the monopolist ensures that consumers are fully willing to pay the additional amount θ_j on its product.

Notice that from a policy perspective Result 4 might suggest caution in the use of production subsidies (decreasing h) aiming to induce investments in high quality (whether certified or not). This is particularly the case in industries where low quality production is prevalent and certification costs are moderate. Both of these conditions are rather common in real life. Equivalent counter-productive results would not arise by using certification subsidies instead. This might well be the reasoning behind the EU strong support to certification of firms´ voluntary practices (e.g. EMAS and Green Flower in the environmental dimension). Moreover, certification subsidies might be worthless in industries where the monopolist is already supplying high (although uncertified) quality. This is illustrated in Figure 1, when $h < f$.

To conclude this section, it is worth mentioning how our results change under simpler versions of the model. Fraud in uncertified production cannot arise in equilibrium in two particular situations. The first case is when higher quality were not a credence good

and consumers could assess product quality after purchase. An implication is that certification is no longer needed, fraud is not possible, and high quality production is more likely in this particular case. [18] This suggests a positive market impact of technologies that are currently under development to track the origin of raw materials by using DNA tests[19] or smart labels[20].

The second is the (unlikely) situation where consumers had perfect information about all the parameters (in particular, the exact values for h and f). In this particular case, consumers would be able to perfectly infer if the firm is actually committing fraud or not by simply comparing f and h. Thus strategy F would not be possible, as it would not be able to induce prices high enough to cover for the additional fraud costs. Notice that the likelihood of certification becomes larger in this particular case (the firm now chooses C instead of F as long as $\pi_L < \pi_C$).

6. Alternative market structures

In this section we extend the baseline model to allow for oligopolistic competition. All the technical details are in the Appendix. We show that the four results highlighted in the previous section are valid under both *Cournot* and *Bertrand* competition, although the possibility of fraud diminishes as long as the number of competing firms increases. Thus, all the policy implications discussed in Section 5 apply in this context as well. Moreover, the competitive market structure can result in the co-existence of certified and uncertified high quality production (truthful or fraudulent) in equilibrium.

[18] In this case, $\pi_H^* = \left(\frac{1-h+\underline{\theta}}{2}\right)^2$, and $\pi_H^* > \pi_L^*$ when $h < \left(\sqrt{\underline{\theta}} - 1\right)^2$.

[19] Forbes, February 12 2016 "Using DNA to fight fabric fraud".

[20] The EU-funded research project Tag it Smart aims to guarantee the traceability of individual *units* of products thoughout its life cycle (http://www.tagitsmart.eu/).

We assume that the market is comprised of N *ex ante* identical firms. Each firm can select one out of the four available strategies, $L, H, F,$ or C. The number of firms following each strategy is denoted as n_i, $i = L, H, F, C$, where $\sum_i n_i = N$. We assume first that firms selecting the same strategy decide the quantity they produce through *Cournot* competition (in the case there were only one firm selecting one particular strategy, it would act as a monopolist for its own variety), and the prices of the different varieties are endogenously determined. The different equilibrium configurations now include the equilibrium quantities, the number of firms adopting each strategy, the associated equilibrium prices, and consumers' beliefs on the truthfulness of uncertified claims.

An important difference with the monopolistic analysis of the previous sections is that consumers can now opt for the different varieties of the product that are simultaneously offered. In equilibrium, firms can follow different strategies even when they are *ex ante* identical. Then, several configurations are possible, ranging from situations where only one variety is offered in equilibrium, to cases where consumers can choose between the three varieties of the product, $L, H,$ or C.

Figure 2 shows the equilibria configurations in the space of (h, c) combinations for given type f firms. For the purpose of illustration, this figure shows a particular case with three competing firms, and where fraud costs f follow a uniform distribution in the support [0,1]. The interested reader can find the general results on oligopolistic competition in the Appendix.

[INSERT FIGURE 2]

A noteworthy common characteristic between Figures 1 and 2 is that configurations where fraud emerges arise for intermediate values of high quality costs. In

Figure 2, this includes scenarios where some firms committing fraud coexist with other firms offering low quality (denoted as LF), and situations where some firms committing fraud coexist with firms marketing both low quality and certified high quality (denoted as LFC).[21]

However, the likelihood of fraud diminishes when the number of competing firms increases. The reason is very intuitive. If the number of competing firms in the industry is large, the profits of the firms offering the different varieties converge. For example, condition $\pi_L = \pi_H = \pi_C$ in configuration LHC determines the number of firms offering each version of the product in equilibrium. Then, in configuration LFC, firms selecting F should mimic the price of honest firms in LHC to gain consumers´ credit. This would imply that the corresponding profits would be larger than those of the firms offering L or C. Consequently some of the firms choosing L or C would have incentives to play F instead, which would result in higher prices than those under honest behavior. This would induce consumers to think that firms offering uncertified high quality are indeed committing fraud, and therefore, α would drop to zero. As a result, the configuration LFC cannot be an equilibrium configuration when the number of competing firms is sufficiently large. For similar reasons, configurations LF or FC cannot arise either.

The only remaining possibility where fraud could arise is in a homogeneous equilibrium where all the firms commit fraud. In this case, all the firms would mimic the price of honest firms in homogeneous configuration H. But the only possibility under which this case can exist is under zero costs of producing high quality, which is a rather unlikely scenario in real life.

[21] In general, configurations where all firms commit fraud (F) or fraudulent firms coexist with firms certifying high quality (FC) are also possible in equilibrium (see the Appendix for details).

If we alternatively assume that the firms compete in prices, each firm can select one out of the four available strategies, $L, H, F,$ or C. Under Bertrand competition, the price of each variety equals marginal cost (and therefore profits are zero) as long as there are at least two firms offering the same variety. Therefore, the only cases where there would be firms obtaining positive profits would be those in which a firm is a monopolist for a particular variety, which occurs only when the number of competing firms is small enough. Firms have weaker incentives to deviate under Bertrand competition than under Cournot, since deviating means harshly competing in prices and therefore obtaining zero profits. But again, the possibility of fraud diminishes when the number of competing firms is large, for the same reasons as those given under Cournot competition.

7. Conclusions

The coexistence of conventional production, voluntary provision of higher quality products, fraud and voluntary certification is common in many market settings. In this paper, we have presented a model that formalizes investments in high quality production in settings where firms can choose to certify their production to outstand in credibility with respect to other firms that truthfully (or not) claim to produce high quality goods. This model is equally applicable to a broad range of quality dimensions, such as employment discrimination, "fair trade", respect for human rights, long-term health implications of products, or environmental aspects including the use of pesticides, genetically modified organisms, and other contexts where high quality presents attributes of a credence good.

The main contribution of this study is that we model the emergence of fraud in uncertified production of high quality and we allow, but do not impose, firms to certify

their products. We show that the interaction between the prospect of fraud in the uncertified variety and the possibility to certify production critically influences market outcomes. Our results suggest that the range of parameter values for which fraud emerges might be smaller than previously considered in some of the literature. Fraud does not emerge when consumers can anticipate that all self-reports on high quality that are not third-party certified are fraudulent. Similarly, we derive new results regarding the potential mechanisms to alleviate fraud. In particular, as opposed to previous literature with a focus on fraud in the use of certification, we show that increasing certification costs might not alleviate, but rather strengthen the prevalence of fraud.

Moreover, we show the existence of a non-monotone relationship between the likelihood of certification and the costs of producing high quality. For a certain range of parameters, certification becomes more attractive as long as the cost of producing high quality increases. However, once consumers´ trust on uncertified claims is sufficiently low, firms are more likely to produce the standard version. Thus, in deciding between the standard and the certified versions, the likelihood of the latter decreases as long as the cost of producing high quality further increase. These two properties define in turn that firms are not necessarily more prone to produce the high quality version as the costs of producing high quality decreases.

An implication of this is that governments should be especially cautious with subsidizing voluntary practices. Such subsidies affect consumers' beliefs on uncertified claims and in turn indirectly modify firms' production decisions, not necessarily entailing stronger investments in high-quality production. Similarly, in light of our results, markets where certification is widespread are not necessarily those where production is of higher quality, because this is mainly needed in contexts where consumers do not trust firms' claims.

Potential extensions of the model could address heterogeneity in consumers' beliefs or firms' costs. The former would account for different perceptions of firms' trustworthiness, since the degree of information or the perceptions formed about a given set of information may well vary across consumers. The model would be technically more complex, but our basic results would continue to hold, as long as consumers´ beliefs on the truthfulness of uncertified claims were decreasing in the cost of producing high quality. Heterogeneity regarding firms´ costs would consider inherent advantages of specific firms in a given production strategy. Again, the main messages regarding the likelihood of fraud, high quality production and certification would be crucially determined by consumers´ beliefs on the truthfulness of uncertified claims.

It is worth noting that we have conducted our analysis assuming that fraud can only be associated to firms' uncertified claims. Thus, we have assumed throughout that certification fully eliminates the asymmetric information problem of consumers, providing a true signal of product quality. This is a simplification of reality, where fraud in the use of certifications also exists. However, the amount of monitoring and control by Public Agencies and NGOs on the trustworthiness of certified products is often larger than that devoted to scrutiny and enforcement associated to fraudulent marketing. Take as an example organic farming certification, where farmers need to follow long and tedious administrative procedures, including on-site visits of production practices. Uncertified agricultural products have used for long similar wording such as "bio", "eco" and alike, in marketing their products to mislead consumers. This use was so prevalent that for example the EU[22] has passed specific regulations controlling the use of misleading wording in the marketing strategy of agricultural products. An interesting area for further research would be to allow for fraud both in the uncertified and certified

[22] Regulation 834/2007

versions of the product, which would require a more complex modeling of consumers' beliefs.

8. Appendix: Oligopolistic Competition

For the purpose of illustration, we describe in detail the way in which configuration LFC is obtained.[23] As in the baseline model, the possibility to offer fraudulent or true uncertified high quality depends on the relationship between the unit cost of producing high quality (h) and the expected cost of committing fraud (f). Consumers´ beliefs are also key in defining the emergence of fraud, and as a consequence, the analysis of configuration LFC is necessarily linked to the analysis of configuration LHC, where true high quality is offered with and without certification. The reason is that firms selecting F in configuration LFC must mimic the price honest firms would set in configuration LHC so that they can falsely gain some credibility (see footnote 15).

Assume a given firms' type f and consider first the case $h < f$. Then, all the firms prefer strategy H over strategy F, as the costs of producing high quality are lower than the expected costs of fraud. This means that strategy F will not be chosen by any firm. Firms can then opt for strategies L, H or C. Assume that a subset of firms n_L select L, a subset of firms n_H offers H, and the remaining firms $n_C = N - n_L - n_H$ offer C. Each consumer derives (expected) surplus from each variety, given by $\underline{\theta} - p_L$; $\underline{\theta} + \alpha\theta_j - p_H$; $\underline{\theta} + \theta_j - p_C$ respectively, and purchases the variety that generates the largest surplus given his consumer type θ_j. Note that the consumer who is indifferent between low and uncertified high quality (that is, the one that derives exactly the same surplus from the two varieties) is $\theta^{LH} = \frac{p_H - p_L}{\alpha}$, and the consumer who is indifferent between uncertified and certified high quality is $\theta^{HC} = \frac{p_C - p_H}{1-\alpha}$. Since $\theta_j \in [0,1]$, and assuming $0 < \theta^{LH} <$

[23] A summary of the results for all the possible configurations is provided in Tables 1 and 2, below.

$\theta^{HC} < 1$, the corresponding aggregate demands for the respective varieties are $Q_L = \frac{p_H - p_L}{\alpha}$; $Q_H = \frac{p_C - p_H}{1-\alpha} - \frac{p_H - p_L}{\alpha}$; $Q_C = 1 - \frac{p_C - p_H}{1-\alpha}$.

Low quality firms select the quantity that maximizes individual profits $\pi_L = q_L p_L$, where $p_L = p_H - \alpha Q_L$ and $Q_L = q_1 + \cdots + q_{n_L}$. The optimal quantity is $q_L = \frac{p_H}{\alpha(n_L+1)}$, and substituting it into the demand function yields the price $p_L = \frac{p_H}{n_L+1}$. Therefore, $q_L = \frac{p_L}{n_L+1}$, which results in profits $\pi_L = \frac{(p_L)^2}{\alpha}$.

Similarly, firms choosing uncertified high quality select the quantity by maximizing $\pi_H = q_H(p_H - h)$, where $p_H = \alpha p_C + (1-\alpha)p_L - \alpha(1-\alpha)Q_H$. The optimal quantity is $q_H = \frac{\alpha p_C + (1-\alpha)p_L - h}{\alpha(1-\alpha)(n_H+1)}$, and substituting this into the corresponding aggregate demand function leads to the price $p_H = \frac{\alpha p_C + (1-\alpha)p_L + h n_H}{n_H+1}$. Then, $q_H = \frac{p_H - h}{\alpha(1-\alpha)}$, which results in $\pi_H = \frac{(p_H - h)^2}{\alpha(1-\alpha)}$.

Finally, firms offering certified high quality select the quantity by maximizing $\pi_c = q_C(p_C - h - c)$, where $p_C = 1 - \alpha + p_H - (1-\alpha)Q_C$. The optimal quantity is $q_C = \frac{1-\alpha+p_H-h-c}{(1-\alpha)(n_C+1)}$. Substituting this into the corresponding aggregate demand function leads to the price $p_C = \frac{1-\alpha+p_H+(h+c)n_C}{n_C+1}$. Then, $q_C = \frac{p_C - h - c}{1-\alpha}$, which results in $\pi_C = \frac{(p_C - h - c)^2}{1-\alpha}$.

Notice that the three prices $p_L = \frac{p_H}{n_L+1}$, $p_H = \frac{\alpha p_C + (1-\alpha)p_L + h n_H}{n_H+1}$ and $p_C = \frac{1-\alpha+p_H+(h+c)n_C}{n_C+1}$ are interrelated, and the unique solution of these three equations yields equilibrium prices conditional on the number of firms following each strategy. The solution for p_H yields:

$$p_H^* = \frac{(n_L+1)\{\alpha[1-\alpha+(h+c)n_C]+hn_H(1+n_C)\}}{(n_L+1)(n_C+1)(n_C+1)-\alpha n_L-(1-\alpha)n_C-1}$$

which can be substituted into the corresponding expressions for p_L and p_C to obtain the remaining equilibrium prices. From these equilibrium prices, the three respective equilibrium quantities and profits can be obtained.

Now consider the alternative case where $h > f$. In this case, no firm will prefer strategy H, which is dominated by strategy F. In configuration LFC, F firms mimic the behavior of H firms in configuration LHC. This means that $p_F^*(\alpha) = p_H^*(\alpha)$ and $\pi_F(\alpha) = \frac{[p_H^*(\alpha)-h][p_H^*(\alpha)-f]}{\alpha(1-\alpha)}$. Since $p_F^*(\alpha) = p_H^*(\alpha)$, the equilibrium prices and profits of the firms selecting L or C in configuration LFC are the same as those in configuration LHC. As in the monopolistic situation, this specific behavior is supported by the equilibrium beliefs $\alpha^*(p_U = p_H{}^*) = \alpha$ and $\alpha^*(p_U \neq p_H{}^*) = 0$, where $\alpha = prob(f \geq h) = 1 - G(h)$.

The remaining configurations are obtained in a similar way, and we summarize all the resulting equilibrium prices and profits in Tables 1 and 2. For configurations offering two varieties, the indifferent consumer between the two varieties delimits the corresponding demands. In homogeneous configurations offering only one variety, all the firms engage in Cournot competition for that variety. The analysis of the configurations where some firms commit fraud is necessarily linked to the analysis of configurations where firms truthfully offer high quality, in the same way as we have explained above.

[INSERT TABLES 1 AND 2 ABOUT HERE]

Now we turn to existence considerations. We focus on the conditions for the emergence of fraud in equilibrium. It is clear that configurations that include the fraudulent strategy (LFC, LF, FC or F) can only arise under the critical condition $f < h$. However, there are additional technical requirements. For example, focusing again on

configuration LFC, there must be a positive demand for each variety, that is, the respective indifferent consumers must be such that $0 < \theta^{LH} < \theta^{HC} < 1$, where $\theta^{LH} = \frac{p_H - p_L}{\alpha}$ and $\theta^{HC} = \frac{p_C - p_H}{1-\alpha}$. Moreover, no firm must have an incentive to deviate to any other strategy, that is, each firm must obtain the largest profits playing that strategy, for given strategies of the remaining firms.

We nowanalyze the specific situation presented in the main text, that is, the case with three firms, each one following one of the possible different strategies, L, F and C, where f follows a uniform distribution in the support $[0,1]$. Based on the previous analysis, for $h > f$, the equilibrium prices of the respective varieties when $n_L = n_F = n_C = 1$ are $p_L = \frac{\alpha(1-\alpha+h+c)+2h}{6}$, $p_F = \frac{\alpha(1-\alpha+h+c)+2h}{3}$ and $p_C = \frac{(3+\alpha)(1-\alpha+c)+(5+\alpha)h}{6}$, and the respective expressions for the indifferent consumers are $\theta^{LF} = \frac{\alpha(1-\alpha+h+c)+2h}{6\alpha}$ and $\theta^{FC} = \frac{(3-\alpha)(1-\alpha+c)+(1-\alpha)h}{6(1-\alpha)}$. Condition $\theta^{LF} > 0$ always holds since $0 < \alpha < 1$. Condition $\theta^{FC} < 1$ is met as long as $c < \frac{(3+\alpha-h)(1-\alpha)}{3-\alpha}$, and condition $\theta^{LF} < \theta^{FC}$ is satisfied whenever $c > \frac{(1-\alpha)(h-\alpha)}{\alpha}$. Given the specific condition on the probability distribution of the type of the firms, consumers' beliefs are $\alpha = 1 - h$, and the two critical conditions for $\theta^{FC} < 1$ and $\theta^{LF} < \theta^{FC}$ reduce respectively to $c < \frac{4h-2h^2}{2+h}$ and $c > \frac{2h^2-h}{1-h}$. Then, there is no demand for the certified version of the product if the first condition does not hold and, consequently, configuration LF arises. Also, there is no demand for the uncertified version of the product if the second condition does not hold and, consequently, configuration LC arises.[24]

[24] Note that for the alternative case where $h < f$, the critical conditions for obtaining configuration LHC are exactly the same as those for obtaining LFC, since the equilibrium prices and the position of the indifferent consumers remain unchanged.

In addition, it is important to verify that in configuration *LFC* (and similarly in the remaining configurations), firms do not have incentives to deviate from its equilibrium strategy to any of the remaining two strategies for given equilibrium choices of the other firms. For the firm playing L, this means that profits in the equilibrium configuration LFC must be (weakly) larger than profits for that firm playing F or C in the equilibrium configuration FC. Similarly, profits for the firm playing F in equilibrium configuration LFC must be (weakly) larger than profits for that firm playing L or C in the equilibrium configuration LC. Finally, profits for the firm playing C in equilibrium configuration LFC must be (weakly) larger than profits for that firm playing L or F in the equilibrium configuration LF.

Combining all different conditions, it is easy to find values of the parameters for which configuration LFC constitutes an equilibrium configuration. Consider, for example, the case where the unit costs of fraud, high quality production and certification are, respectively, $f = 0$, $h = 0{,}4$ and $c = 0{,}12$. Under this specification, the corresponding equilibrium prices for the three varieties are $p_L = 0{,}23$, $p_U = 0{,}45$ and $p_C = 0{,}69$, and the respective profits are $\pi_L = 0{,}085$, $\pi_U = 0{,}10$ and $\pi_C = 0{,}068$. Since $f < h$, the firm offering uncertified high quality is actually committing fraud. The firm producing L does not have incentives to deviate to any of the other two strategies given the choices of the other firms (it would be obtaining 0,081 and 0,05 if it deviated to F or C, respectively). The firm selecting F does not have incentives to deviate to any of the other two strategies either given the choices of the other firms (it would be obtaining 0,09 in any of the two deviations to L or C, respectively). Finally, the firm selecting C does not

have incentives to deviate to any of the other two strategies either (it would be obtaining 0,08 and 0,04 if it deviated to L or F, respectively).[25]

[25] Table 2 summarizes the profits for each firm under the different equilibrium configurations. Then, to obtain the deviation profits of the firm playing L in configuration LFC with three firms, we have computed the profits for a firm playing F in the configuration FC where two firms play F and one firm plays C, and also the profits for a firm playing C in the configuration FC where one firms play F and two firms plays C. Similar comments apply to the remaining equilibria.

References

Akerlof, George A. 1970. The market for “lemons”: Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics 84* (3): 488-500.

Amacher, Gregory S., Erkki Koskela, and Markku Ollikainen. 2004. Environmental quality competition and eco-labeling. *Journal of Environmental Economics and Management 47* (2): 284-306.

Arora, Seema, and Shubhashis Gangopadhyay. 1995. Toward a theoretical model of voluntary overcompliance. *Journal of Economic Behavior and Organization 28* (3): 289-309.

Baksi, Soham, and Pinaki Bose. 2007. Credence goods, efficient labelling policies, and regulatory enforcement. *Environmental and Resource Economics 37* (2): 411-430.

Baksi, Soham, Pinaki Bose, and Di Xiang. 2016. Credence goods, misleading labels, and quality differentiation. *Environmental and Resource Economics*: 1-20.

Bansal, Sangeeta, and Shubhashis Gangopadhyay. 2003. Tax/subsidy policies in the presence of environmentally aware consumers. *Journal of Environmental Economics and Management 45* (2, Supplement): 333-355.

Baron, David P. 2011. Credence attributes, voluntary organizations, and social pressure. *Journal of Public Economics 95* (11‚Äì12): 1331-1338.

Becker, Gary S. 1968. Crime and punishment: An economic approach. *Journal of Political Economy 76* (2): 169-217.

Becker-Olsen, Karen L., B. Andrew Cudmore, and Ronald Paul Hill. 2006. The impact of perceived corporate social responsibility on consumer behavior. *Journal of Business Research 59* (1): 46-53.

Cho, In-Koo, and David M. Kreps. 1987. Signaling games and stable equilibria. *The Quarterly Journal of Economics 102* (2): 179-221.

Conrad, Klaus. 2005. Price competition and product differentiation when consumers care for the environment. *Environmental and Resource Economics 31* (1): 1-19.

Darby, Michael R., and Edi Karni. 1973. Free competition and the optimal amount of fraud. *The Journal of Law & Economics 16* (1): 67-88.

Dranove, David, and Ginger Zhe Jin. 2010. Quality disclosure and certification: Theory and practice. *Journal of Economic Literature 48* (4): 935-963.

Dulleck, Uwe, and Rudolf Kerschbamer. 2006. On doctors, mechanics, and computer specialists: The economics of credence goods. *Journal of Economic Literature 44* (1): 5-42.

Dulleck, Uwe, Rudolf Kerschbamer, and Matthias Sutter. 2011. The economics of credence goods: An experiment on the role of liability, verifiability, reputation, and competition. *American Economic Review 101* (2): 526-555.

Emons, Winand. 1997. Credence goods and fraudulent experts. *The RAND Journal of Economics 28*: 107-119.

Farhi, Emmanuel, Josh Lerner, and Jean Tirole. 2013. Fear of rejection? Tiered certification and transparency. *The RAND Journal of Economics 44* (4): 610-631.

Feddersen, Timothy J., and Thomas W. Gilligan. 2001. Saints and markets: Activists and the supply of credence goods. *Journal of Economics & Management Strategy 10* (1): 149-171.

Fischer, Carolyn, and Thomas P. Lyon. 2014. Competing environmental labels. *Journal of Economics & Management Strategy 23* (3): 692-716.

Fishman, Michael J., and Kathleen M. Hagerty. 1990. The optimal amount of discretion to allow in disclosure. *The Quarterly Journal of Economics 105* (2): 427-444.

Fudenberg, Drew, and Jean Tirole. 1991. *Game theory*. Cambridge: MIT Press.

Glaeser, Edward L., and Gergely Ujhelyi. 2010. Regulating misinformation. *Journal of Public Economics 94* (3–4): 247-257.

Grossman, Sanford J. 1981. The informational role of warranties and private disclosure about product quality. *Journal of Law and Economics 24*: 461-483.

Grossman, Sanford J. , and Oliver D. Hart. 1980. Disclosure laws and takeover bids. *The Journal of Finance 35*: 323-334.

Hamilton, Stephen F., and David Zilberman. 2006. Green markets, eco-certification, and equilibrium fraud. *Journal of Environmental Economics and Management 52* (3): 627-644.

Harbaugh, Rick, John W. Maxwell, and Beatrice Roussillon. 2011. Label confusion: The groucho effect of uncertain standards. *Management Science 57* (9): 1512-1527.

Heyes, Anthony G., and John W. Maxwell. 2004. Private vs. Public regulation: Political economy of the international environment. *Journal of Environmental Economics and Management 48* (2): 978-996.

Heyes, Anthony, and Steve Martin. forthcoming. Social labeling by competing ngos: A model with multiple issues and entry. *Management Science*: http://dx.doi.org/10.1287/mnsc.2015.2419.

Khanna, Madhu. 2001. Non-mandatory approaches to environmental protection. *Journal of Economic Surveys 15* (3): 291-324.

Kitzmueller, Markus, and Jay Shimshack. 2012. Economic perspectives on corporate social responsibility. *Journal of Economic Literature 50* (1): 51-84.

Kotchen, Matthew J. 2005. Impure public goods and the comparative statics of environmentally friendly consumption. *Journal of Environmental Economics and Management 49* (2): 281-300.

---. 2006. Green markets and private provision of public goods. *Journal of Political Economy 114* (4): 816-834.

---. 2013. Voluntary- and information-based approaches to environmental management: A public economics perspective. *Review of Environmental Economics and Policy 7* (2): 276-295.

Lyon, Thomas P., and John W. Maxwell. 2008. Corporate social responsibility and the environment: A theoretical perspective. *Review of Environmental Economics and Policy 2* (2): 240-260.

---. 2011. Greenwash: Corporate environmental disclosure under threat of audit. *Journal of Economics & Management Strategy 20* (1): 3-41.

Mason, Charles F. 2006. An economic model of ecolabeling. *Environmental Modeling and Assessment 11* (2): 131-143.

---. 2011. Eco-labeling and market equilibria with noisy certification tests. *Environmental and Resource Economics 48* (4): 537-560.

Matthews, Steven, and Andrew Postlewaite. 1985. Quality testing and disclosure. *The RAND Journal of Economics 16*: 328-340.

Milgrom, Paul R. 1981. Good news and bad news: Representation theorems and applications. . *The Bell Journal of Economics 12* (2).

Moraga-González, José Luis, and Noemi Padrón-Fumero. 2002. Environmental policy in a green market. *Environmental and Resource Economics 22* (3): 419-447.

Okuno-Fujiwara, Masahiro, Andrew Postlewaite, and Kotaro Suzumura. 1990. Strategic information revelation. *The Review of Economic Studies 57*: 25-47.

Portney, Paul R. 2008. The (not so) new corporate social responsibility: An empirical perspective. *Review of Environmental Economics and Policy 2* (2): 261-275.

Sankar Sen, and C.B. Bhattacharya. 2001. Does doing good always lead to doing better? Consumer reactions to corporate social responsibility. *Journal of Marketing Research 38* (2): 225-243.

Sedjo, Roger A., and Stephen K. Swallow. 2002. Voluntary eco-labeling and the price premium. *Land Economics 78* (2): 272-284.

Shavell, Steven. 1994. Acquisition and disclosure of information prior to sale. *The RAND Journal of Economics 25*: 20-36.

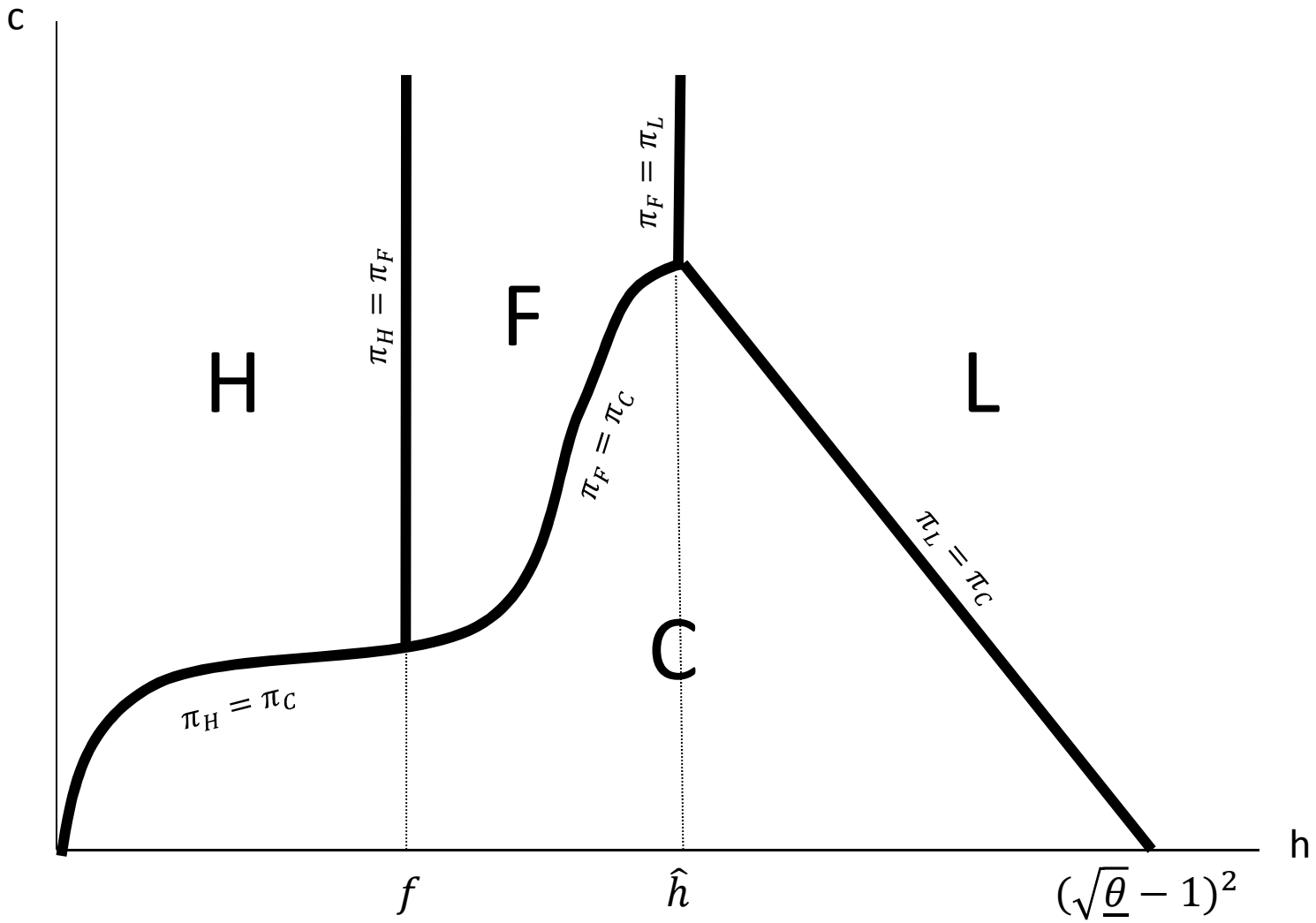

Figure 1. Equilibrium strategies for type f monopolist

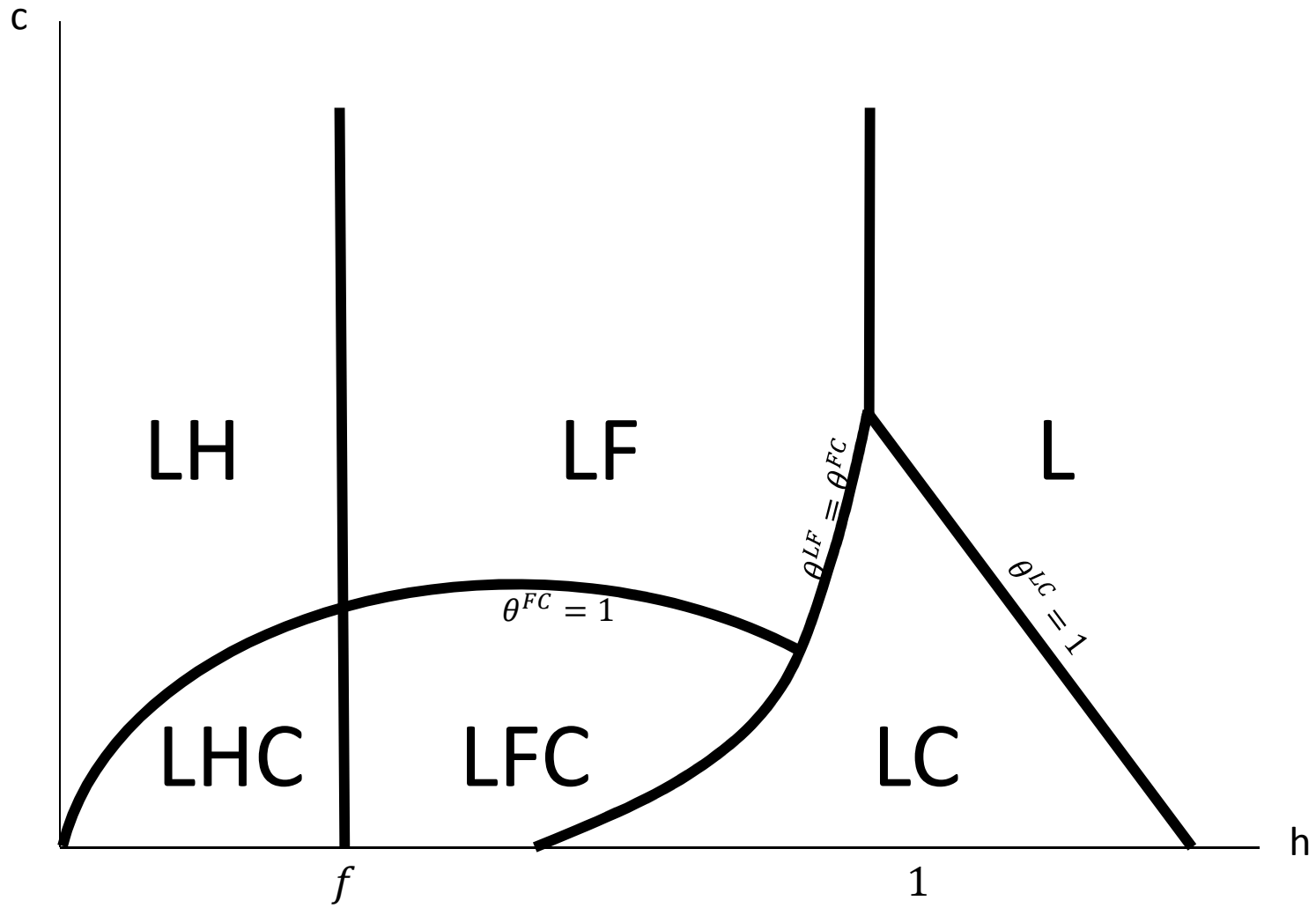

Figure 2. Equilibrium configurations under Cournot oligopoly

CONF.	p_L	p_U	p_C
L	$\underline{\theta}$	-	-
F	-	$\frac{\alpha+\underline{\theta}+hN}{N+1}$	-
H	-	$\frac{\alpha+\underline{\theta}+hN}{N+1}$	-
C	-	-	$\frac{1+\underline{\theta}+(h+c)N}{N+1}$
LF	$\frac{\propto+hn_H}{(n_L+1)(n_H+1)-1}$	$(n_L+1)\frac{\propto+hn_H}{(n_L+1)(n_H+1)-1}$	-
LH	$\frac{\propto+hn_H}{(n_L+1)(n_H+1)-1}$	$(n_L+1)\frac{\propto+hn_H}{(n_L+1)(n_H+1)-1}$	-
LC	$\frac{1+(h+c)n_C}{(n_L+1)(n_C+1)-1}$	-	$(n_L+1)\frac{1+(h+c)n_C}{(n_L+1)(n_C+1)-1}$
FC	-	$\frac{1-\propto+hn_H(n_C+1)+(h+c)n_C}{(n_H+1)(n_C+1)-1}$	$\frac{(1-\propto)(n_H+1)+hn_H+(h+c)n_C(n_H+1)}{(n_H+1)(n_C+1)-1}$
HC	-	$\frac{1-\propto+hn_H(n_C+1)+(h+c)n_C}{(n_H+1)(n_C+1)-1}$	$\frac{(1-\propto)(n_H+1)+hn_H+(h+c)n_C(n_H+1)}{(n_H+1)(n_C+1)-1}$
LFC	$\frac{\propto[1-\propto+(h+c)n_C]+hn_H(1+n_C)}{(n_L+1)(n_H+1)(n_C+1)-\propto n_L-(1-\propto)n_C-1}$	$\frac{(n_L+1)\{\propto[1-\propto+(h+c)n_C]+hn_H(1+n_C)\}}{(n_L+1)(n_H+1)(n_C+1)-\propto n_L-(1-\propto)n_C-1}$	$\frac{1-\propto+(h+c)n_C}{n_C+1}+\frac{p_U}{n_C+1}$
LHC	$\frac{\propto[1-\propto+(h+c)n_C]+hn_H(1+n_C)}{(n_L+1)(n_H+1)(n_C+1)-\propto n_L-(1-\propto)n_C-1}$	$\frac{(n_L+1)\{\propto[1-\propto+(h+c)n_C]+hn_H(1+n_C)\}}{(n_L+1)(n_H+1)(n_C+1)-\propto n_L-(1-\propto)n_C-1}$	$\frac{1-\propto+(h+c)n_C}{n_C+1}+\frac{p_U}{n_C+1}$

TABLE 1. Equilibrium prices in the respective configurations under Cournot competition

CONF.	π_L	π_U	π_C
L	$\underline{\theta}/N$	-	-
F	-	$\frac{(\alpha+\underline{\theta}-h)(\alpha+\underline{\theta}-f)}{\propto (N+1)^2}$	-
H	-	$\frac{1}{\propto}\left(\frac{\alpha+\underline{\theta}-h}{N+1}\right)^2$	-
C	-	-	$\left(\frac{1+\underline{\theta}-h-c}{N+1}\right)^2$
LF	$\frac{(\propto+hn_H)^2}{\propto[(n_L+1)(n_H+1)-1]^2}$	$\frac{[(n_L+1)\propto-hn_L][(n_L+1)\propto-fn_L]}{\propto[(n_L+1)(n_H+1)-1]^2}$	-
LH	$\frac{(\propto+hn_H)^2}{\propto[(n_L+1)(n_H+1)-1]^2}$	$\frac{\{(n_L+1)\propto-hn_L\}^2}{\propto[(n_L+1)(n_H+1)-1]^2}$	-
LC	$\frac{[1+(h+c)n_C]^2}{[(n_C+1)(n_L+1)-1]^2}$	-	$\frac{[n_L+1-(h+c)n_L]^2}{[(n_C+1)(n_L+1)-1]^2}$
FC	-	$\frac{(1-\propto+cn_C)\left[1-\propto+cn_C+(h-f)\left(n_C+hn_H(n_C+1)\right)\right]}{(1-\propto)[(n_H+1)(n_C+1)-1]^2}$	$\frac{\{(1-\propto)(n_H+1)-cn_H\}^2}{(1-\propto)[(n_H+1)(n_C+1)-1]^2}$
HC	-	$\frac{(1-\propto+cn_C)^2}{(1-\propto)[(n_H+1)(n_C+1)-1]^2}$	$\frac{\{(1-\propto)(n_H+1)-cn_H\}^2}{(1-\propto)[(n_H+1)(n_C+1)-1]^2}$
LFC	$\frac{(p_L)^2}{\propto}$	$\frac{(p_U-h)(p_U-f)}{\propto(1-\propto)}$	$\frac{(p_C-h-c)^2}{1-\propto}$
LHC	$\frac{(p_L)^2}{\propto}$	$\frac{(p_U-h)^2}{\propto(1-\propto)}$	$\frac{(p_C-h-c)^2}{1-\propto}$

TABLE 2. Equilibrium profits in the respective configurations under Cournot competition