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Why is price useless to signal environmental quality ?

Alexandre Volle*[1]

Abstract— **The present paper investigates the pricing behavior of a green firm competing against a brown firm where the polluting good is sold in a perfect competitive market. The distorsion of the price to signal a green product is too great to face any demand. Pooling price equilibria emerge as most plausible as long as the brown firm has the possibility to mimic the pricing behavior of the green firm. A green producer is thus constrained to practice uninformative prices which can conduct it to leave the market.**

Keywords— Credence Attributes, Asymmetric Information, Price Signaling
JEL *classification*— D43, D82, Q5

I. Introduction

Can the price transmit information on environmental quality of a credence good ?

The idea that the price can ensure the correct transmission of information has been largely developed since Milgrom and Roberts (1986). In this literature (Bagwell & Riordan, 1991; Mahenc, 2007; Daughety & Reinganum, 2008) it is shown that the price ensures the revelation of information. However authors have to do important specifications to ensure the existence of the market and to raise the possibility for firms to reveal their type.

In this article, I examine the consequence of incomplete information on price signal in the context of a Duopoly. Whereby it produces vertically differentiated substitute goods according to an environmental attribute. Firms quality is exogenously determined; it can be green (high) or brown (low) and they operate in a one-shot (three period) model. The main specification is that the brown market is perfectly competitive.

I find that firms do not achieve separation in price and it implies that price cannot transmit any information about the type of the firm when one of the two segment is perfectly competitive. This result is strengthened by using the most common equilibrium refinement in price signaling literature to show that it selects the lonely separating implausible price.

While it appears impossible for the green firm to reveal its type, it is still possible that the market exists by forcing the green firm to pool with the brown type. Pooling equilibria, in the case of green markets, may be assimilated to Greenwashing as long as these equilibria correspond to a case where the brown firm makes a misleading claim about the environmental benefits of a product. The recent Volkswagen scandal is a prime example of this where, as stated in Forbes[1]: «company leaders had the option to attempt to reap the benefits of being green by merely giving the appearance of an environmentally friendly company on the outside, without making the necessary investments on the inside». Moreover as mentioned in the Guardian[2] the means used for Greenwashing can take different form, such as a combination of advertising and higher priced products[3], as long as it provides information that misleads consumers into thinking they are helping the environment.

Fortunately the transmission of the correct information on environmental quality can notably rely on certification (Bonroy & Constantatos, 2008) to solve the problem of asymmetric information and to ensure the existence of green markets. There exist natural links between the price and the certification. One of the main argument of the certifiers for label adoption is that consumers are ready to pay a price premium for a green product. Thereby when a green product is credibly identified green producers can extract this surplus by charging a higher price. Nevertheless recently there has been an increasing phenomenon of lack of trust towards eco-labels[4] (Jacquet et al., 2010) and green certification (Hamilton & Zilberman, 2006; Mason, 2011). Washington and Ababouch (2011) in the same time made a report wherein they questioned the reality of price premium associated to eco-labels in fish industry. While there are evidences of this premium for fish retailers, this relation is not established for fish producers (Blomquist, Bartolino, & Waldo, 2015). The report mentioned that there has been no price premium gained from certification for the case of Alaska pollock and pointed to the fact that uncertified Russian pollock was fetching similar prices on the European market. Albeit it is important to mention that in this market the over-riding factor that sets price is still quality, it remains that environmental groups raised objections about the sustainability of the fisheries concerning the Alaska pollock certification. An explanation provided by this analysis is that when the environmental differentiation is not credibly displayed by the certification, an immediate consequence is that green producers are constrained to practice pooling prices to stay in the market. They cannot signal their environmental quality through prices because (1) it corresponds to credence at-

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[1] Forbes 15/09/2016: How To Succeed At Sustainability (And Why Greenwashing Doesn't Work)

[2] The Guardian 20/08/2016: The troubling evolution of corporate greenwashing

[3] The Guardian 25/05/2014: Five sustainable boondoggles: greenwashing all the way to the bank

[4] Le Monde Diplomatique 01/06/2017: Un label agricole toujours moins exigeant

tributes and (2) some of standard firms would have incentives to mimic any green prices.

The remainder of the paper is organized as follows. Section 2 below relates the article to the existing literature. Section 3 provides the model, extensions and results. Section 4 discusses the implication of results.

II. Relation to the Existing Literature

The transmission of information regarding environmental quality can be characterized as vertical or horizontal, according to whether it triggers or not, unanimous consumer reactions (Bonroy & Constantatos, 2008). Nevertheless the literature treats environmental quality as an excludable characteristic of the good and mainly assume that adopting a green production is more costly than a standard process (Amacher, Koskela, & Ollikainen, 2004; Hamilton & Zilberman, 2006; Mahenc, 2007). Therefore there is an indisputable necessity to signal the quality or else fall into the lemon outcome (Akerlof, 1970). On this article I focus on the price only to provide information. Price signaling literature revealed some important insights on the link between incomplete information market and price strategies.

Milgrom and Roberts (1986) mostly identify various conditions to ensure existence of separating equilibria between low and high quality type. However they find the existence of pooling equilibria if consumers beliefs are high enough. This result comes from that the distorsion of the price required to reveal the information may be less attractive when consumers are very optimistic about the quality. Repeat purchases play a major role in the trade-off between the choice to signal by price and/or advertising.

Bagwell and Riordan (1991) show that in a two-types of quality model that in equilibrium firms choose separating prices. It remains a price distorsion for the high quality firm but for the low quality it has no incentive to deviate because of the informed consumers it would loose great sales volume.

Daughety and Reinganum (2008) provide a complete model in which the low quality is associated to a disutility parameter. They examine the interplays of imperfect competition and incomplete information. There are two sources of incomplete information (adverse selection and firms anticipations) nevertheless in equilibrium firms charge the separating prices. Even when the disutility is strong and thus inciting low quality to mimic the high segment, the high-quality firm raises its price even further to signal its quality.

Mahenc (2007) examines a model which involve a monopolist using price to signal quality and shows that a firm has incentive to disclose its quality as long as consumers do not have too optimistic beliefs. He underlines that the distorsion caused by the signaling occurs when the firm chooses the fully informative price and concludes that the monopolist charges higher price in the case of incomplete information.

It is noteworthy to mention that in all of these studies, firms have the possibility to transmit information on quality through prices.

III. Model

A. *Perfect Information*

One starts by defining the model of perfect information to use it as a benchmark. In the model I assume that there are two qualities of goods corresponding to two types $\theta_i \in \Theta$ of firms, $i = g$ (green quality) and $i = b$ (brown quality). Environmental quality refers here to the cleanness of production.

I normalize the number of consumers to 1 and I assume that the utility of consumers of a brown good is homogenous and denoted as follows:

$$v - p_b$$

Where v denotes the reservation price of brown consumers for the good and p_b its price. $v > p_b$ otherwise it would not be socially profitable to produce the good. The utility of consumers of a green good is heterogeneous and defined as follow:

$$v + s_j - p_g$$

Where s_j can be interpreted as each consumer's reservation price for the environmental service provided by the firm. Moreover s_j is uniformly distributed among $[0, \alpha e]$ where e is the effort provided by the green firm and it is combined with the intrinsic valuation for the environmental service α_j of each green consumers. The upper bound αe represents the reservation price of the household which values the most the environmental service. To ensure that the production of the green good is socially desirable one has to assume that $\alpha > 1$. When the effort is high, or the valuation is large, green consumers are ready to spend more. This framework is similar as Mussa and Rosen (1978). I denote $\tilde{s}$ the customer which is indifferent between consuming the green good and the brown good. In this case the market is assumed to be fully-covered.

$$v - p_b = v + \tilde{s} - p_g$$

$$\tilde{s} = p_g - p_b$$

Both demands $Q_b(p_b, p_g)$ and $Q_g(p_b, p_g)$ are defined by $\tilde{s}$ such that:

$$Q_g(p_g, p_b) = \begin{cases} 1 - \frac{p_g - p_b}{\alpha e} & \text{if } \alpha > \frac{p_g - p_b}{e} \\ 0 & \text{otherwise} \end{cases} \tag{1.1}$$

$$Q_b(p_g, p_b) = \begin{cases} \frac{p_g - p_b}{\alpha e} & \text{if } p_g > p_b \\ 0 & \text{otherwise} \end{cases} \tag{1.2}$$

Concerning the supply side I assume that firms compete in a simplified Bertrand Duopoly framework. I assume that the price of the brown market corresponds to the perfectly competitive price $p_b = c$. I assume that they have both a linear marginal cost to produce the good such that $c(\theta_i, q_i) = cq_i$ and that the green firm in order to produce a cleaner good has a variable abatement cost such that $c(\theta_g, q_g) = (c+e)q_g$. Where $e \in]0, 1]$ is the effort of the firm and it is assumed exogenously determined. The effort cannot be null because the preferences of Mussa and Rosen (1978) need that green firm which benefits from green demand is at least endowed with the minimum effort possible to be differentiated from

the brown firm. Firm producing green quantity solves the following program:

$$\max_{p_g} \pi(\theta_g, p_g) = (p_g - c - e)\left(1 - \frac{p_g - c}{\alpha e}\right) \tag{1.3}$$

$$p_g^* = \frac{\alpha e}{2} + \frac{e}{2} + c \tag{1.4}$$

Even if the brown firm uses a perfect competitive price, the structure of the analysis corresponds to a price competition through product differentiation which is closely related to Shaked and Sutton (1982). The level of the effort of abatement of the firm here appears as the level of differentiation in a standard model. One can check the classic result that when $\lim_{e \to 0} p_g(e) \to p_b = c$. For $e = 1$ products are very differentiated and the price competition between firms is softened as a result the price of the green firm increases.

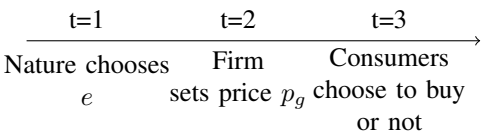
The profit equilibrium of the green firm is given by:

$$\pi(\theta_g, p_g^*) = \frac{e(\alpha - 1)^2}{4} \tag{1.5}$$

B. Imperfect Information: Adverse Selection

In this subsection the problem of asymmetric information occurs on the green market. Environmental attribute associated to the cleanness of production is defined as a *credence attribute*. Although consumers do not directly observe the environmental performance of the product, the price of the green good can be taken as a signal of the environmental quality. Let $\mu(p) = \mu \to [0, 1]$ denotes consumers' posterior belief that the product is truly green when the price is p. Nevertheless firms are perfectly informed on the type of their rival. When information is not complete, the game among the firms and consumers occurs in (one-shot) three stages.

Figure I
The Signaling Game



The utility of green customers is now:

$$v + \mu(p)s_j - p_g$$

$$\tilde{s} = \frac{p_g - c}{\mu(p)}$$

The program of the green firm is now given by:

$$\max_{p_g} \pi(\theta_g, p_g) = (p_g - c - e)\left(1 - \frac{p_g - c}{\alpha e \mu}\right) \tag{2}$$

The equilibrium prices, quantities and profits are now:

$$Q_g^*(p_g) = \begin{cases} \frac{(a\mu - 1)}{2\mu} & \text{if } \mu > \frac{1}{\alpha} \\ 0 & \text{otherwise} \end{cases} \tag{2.1}$$

$$Q_b^*(p_g) = \frac{e(a\mu + 1)}{2\mu} \tag{2.2}$$

$$p_g^* = \frac{1}{2} ae\mu + \frac{1}{2} e + c \tag{2.3}$$

$$\pi_g^* = \frac{1}{4} \frac{e(a\mu - 1)^2}{\mu} \tag{2.4}$$

Intuitively the total amount of green quantity (2.1) is an increasing function of the perception of green customers. The condition on μ guarantees that the market exists if consumers are not too pessimistic about the environmental attribute of the good. The green firm prefers consumers beliefs about environmental performance to be optimistic. Conversely the total amount of brown quantity (2.2) is a decreasing function of μ because of the effect of substitution between the two kind of goods. Equations (2.3) and (2.4) show that the posterior belief of green customers is a parameter which acts in favour of softening competition for the green firm by increasing differentiation. Concerning (2.4) it reaches its maximum when the differentiation is at its highest state and the information is perfect.

For the green firm the problem is to choose the price to maximize its profit taking into account consumers updated beliefs. The particularity here is that even if the brown firm experiences a competitive market, one assumes that it has the possibility to choose between the informative price, which is equal to the marginal cost, or to mimic the green price. The set of strategies and beliefs which characterize the Perfect Bayesian Equilibrium (P.B.E) is $(\phi(\theta_g), \phi(\theta_b), \mu(p))$ where $\phi(\theta_g)$ and $\phi(\theta_b)$ are the strategy of the green and the brown firm and one assumes that the three conditions are met to ensure the existence of a P.B.E. (Mas-Colell, Whinston, Green, et al., 1995).

1) Separating Equilibrium

In any separating P.B.E, $\phi(\overline{\theta_g}) \neq \phi(\overline{\theta_b})$; that is, information is revealed so that $\mu(p) = 1$ and each type of firm receives a profit equal to its environmental level.

Sufficient conditions to ensure the existence of a separating equilibrium are given by incentives constraints for each type:

$$\pi(\theta_g, \phi_g(\overline{\theta}), 1) \geq 0 \tag{3.1}$$

$$\pi(\theta_b, \phi_b(\overline{\theta}), 1) \geq \pi(\theta_b, \phi(\theta), \mu_0) \tag{3.2}$$

(3.1) and (3.2) ensure that profits of each type benefit from the best beliefs of consumers and guarantee that informative prices are attractive.

Proposition 1: *it exists only one separating equilibrium price such that* $\phi(\theta_g) \neq \phi(\theta_b)$ *where* $\phi(\overline{\theta_g}) = ae\mu + c$ *and* $\phi(\overline{\theta_b}) = c$ *yielding profits of* $\pi(\theta_b, \phi(\overline{\theta_b}), 1) = \pi(\theta_g, \phi(\overline{\theta_g}), 1) = 0$.

Proof. Straightforward calculation on (2) shows that there is a continuum of possible price which would satisfy constraint (3.1) with $\phi(\theta_g) \in [c + e; ae\mu + c]$. Condition (3.2) gives the incentive constraint of the brown firm. By assumptions, one knows that if the information is revealed then the brown firm is price taker and thus make a profit equal to zero. The only price which satisfies condition (3.1) and condition (3.2) is $\phi(\theta_g) = ae\mu + c$. At this point for

the brown firm it is indifferent between $\pi(\theta_b, \phi(\overline{\theta_b}), 1) = 0$ and $\pi(\theta_b, \phi(\overline{\theta_b}), 1) = 0$.

Note that when the green firm sets this price the demand $Q_g(p, \mu) = 0$. To explain this result, recall that the brown market is perfectly competitive, so that profits are zero for the brown firm. Therefore (3.2) can only hold if the right-hand side is nonpositive. Since production costs are stricty lower for the brown firm, this can only happen when the demand for the green firm is zero.

*2) **Pooling Equilibria***

Because the profit is null in the case of separating equilibrium, pooling equilibria appear more plausible in the model. Since it is the same (uninformative) price charged by the firms, regardless of environmental performance, the consumers' posterior beliefs after observing the price are the same as their prior beliefs denoted μ_0. Recall from Section 1 that the nature of these equilibria in this model is closely related to Greenwashing because it corresponds to a case where the brown firm by equalizing its price to the green firm claims to be environmentally friendly. If such phenomenon is revealed one cannot be very optimistic about the beliefs of consumers and the sustainability of such market because of the condition (2.1).

In any pooling P.B.E., $\phi(\underline{\theta_g}) = \phi(\underline{\theta_b})$; that is, where the green and the brown firm have no incentive to reveal their type.

The incentive constraint of both type are:

$$\pi_g(\theta_g, \phi(\underline{\theta_g}), \mu_0) > \pi_g(\theta_g, \phi(\theta_g), 1) \tag{4.1}$$

$$\pi_b(\theta_b, \phi(\underline{\theta_b}), \mu_0) > \pi_b(\theta_b, \phi(\theta_b), 1) \tag{4.2}$$

Proposition 2: *there exists a continuum of pooling equilibria such that* $\phi(\theta_g) = \phi(\theta_b) \in]c + e; ae\mu + c[$.

Proof. There are a continuum of possible prices for the green firm which satisfy (4.1). The brown firm has a larger set of possible price (4.2) due to the fact that it does not pay abatement cost. Anyway the set of possible price is reduced to the set of the green firm because of the definition of PBE.

Figure II
Summary of the Signaling Game

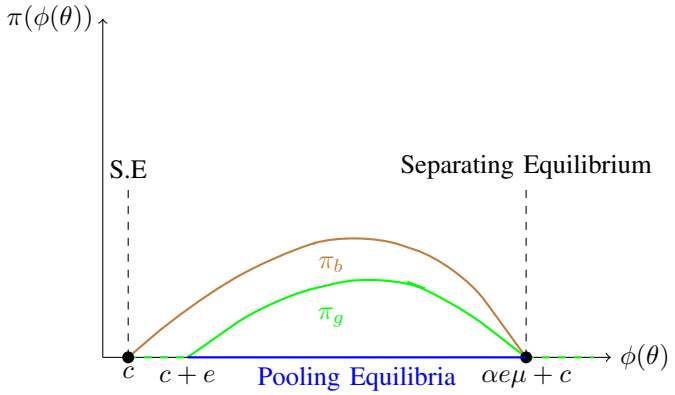


Figure II describes a situation between the green and the brown firm. These curves are drawn according to specific posterior beliefs μ of green customers. Brown curve is the profit of the brown type and green curve is the profit of the green type given the chosen price. Dashed green lines on the horizontal axis represent the space where the green firm would not operate given these prices.

*3) **Intuitive Criterion***

Facing the multiplicity of equilibrium there is a necessity to use a a refinement concept. Price signals literature usually use the intuitive criterion (Cho & Kreps, 1987) to select a unique separating equilibrium(Milgrom & Roberts, 1986; Bagwell & Riordan, 1991; Daughety & Reinganum, 2008).

Proposition 3: *Intuitive Criterion rules-out every pooling equilibria*

Proof. *Appendix 1*.

It is interesting to underline that the the common refinement used in price literature crowds-out every equilibria associated to positive profits for firms and selects the lonely separating price yielding a null demand. It also bolsters the idea that the green firm cannot use the price as a signal.

IV. Discussion

Facing this extreme result it is important to keep in mind that price signaling literature also showed that above a critical size of informed consumers, signaling is feasible with full-information prices (Belleflamme & Peitz, 2015). This is not a new idea in price competition that a share of informed consumer may be extremely efficient as long as it has sufficient impact on the incentives constraints either of the low-quality firm as in Bagwell and Riordan (1991) or the high-quality firm. In this study the effect of the share of informed consumer on the price is not that clear. While it would clearly support the green firm by ensuring it a better profit the brown firm would have no incentives to deviate from pooling equilibrium as long as its incentive constraint is not negatively impacted.

This analysis constitutes a case where assumptions to ensure the existence of a separating equilibria associated to positive payoffs do not hold (Milgrom & Roberts, 1986) or where the disutility associated to the polluting product is very high (Daughety & Reinganum, 2008). Mentioned but less highlighted than separating equilibria, pooling equilibria remain problematic. The case of credence attribute market in environment constitute an interesting situation as long as repetitive purchase cannot provide any informations. Knowing that some brown firms have incitations to fraud (Hamilton & Zilberman, 2006) one can easily imagine a market where a polluting firm which experiences low-profit may be tempted to use a pooling price as long as punishments and regulations are not efficient enough. Finally this study points out the importance of the credibility of the means to provide information as lobbying (Feddersen & Gilligan, 2001) and certification (Bonroy & Constantatos, 2008; Ibanez & Grolleau, 2008) otherwise green information could not be revealed.

A. Appendix 1

Proof of Proposition 3

To simplify notations I note that $\pi_{\theta_i} = \pi_i$.
An equilibrium ϕ^* is said to violate the Intuitive Criterion if $\exists\ \phi' > \phi^*$ with $\mu(\phi') = 1$ such that:

$$\pi_b(\phi^*, \mu_0) \geq \pi_b(\phi', 1) \tag{5.1}$$

$$\pi_g(\phi^*, \mu_0) < \pi_g(\phi', 1) \tag{5.2}$$

The left hand sides are equilibrium payoffs whereas the right hand sides are the maximum payoff that each type could get by setting a price ϕ'.
• Consider a ϕ' s.t $\pi_b(\phi^*, \mu_0) = \pi_b(\phi', 1)$ which can be rewritten

$$(\phi^* - c)Q_g(\phi^*, \mu_0) = (\phi' - c)Q_g(\phi', 1) \tag{5.3}$$

One verifies (5.2):

$$\begin{aligned} \pi_g(\phi^*, \mu_0) = &\quad \pi_b(\phi^*, \mu_0) - eQ_g(\phi^*, \mu_0) \\ = &\quad \pi_b(\phi', 1) - eQ_g(\phi^*, \mu_0) \\ \pi_g(\phi', 1) = &\quad \pi_b(\phi', 1) - eQ_g(\phi', 1) \end{aligned}$$

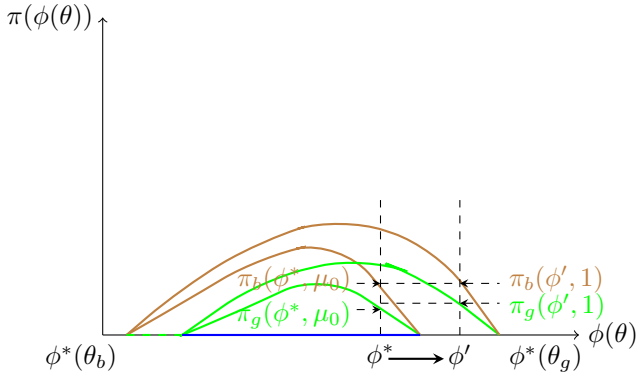
With (5.3) $Q_g(\phi^*, \mu_0) = \left(\frac{\phi' - c}{\phi * - c}\right) Q_g(\phi', 1)$

$$Q_g(\phi', 1) < Q_g(\phi^*, \mu_0)$$

$$Q_g(\phi', 1) < \left(\frac{\phi' - c}{\phi * - c}\right) Q_g(\phi', 1)$$

It implies that $\phi' > \phi^*$ and verifies the definition.
QED.

Figure III
Graphic associated to the proof



References

Akerlof, G. A. (1970). The market for" lemons": Quality uncertainty and the market mechanism. *The quarterly journal of economics*, 488–500.

Amacher, G. S., Koskela, E., & Ollikainen, M. (2004). Environmental quality competition and eco-labeling. *Journal of Environmental Economics and Management*, *47*(2), 284–306.

Bagwell, K., & Riordan, M. H. (1991). High and declining prices signal product quality. *The American Economic Review*, 224–239.

Belleflamme, P., & Peitz, M. (2015). *Industrial organization: markets and strategies*. Cambridge University Press.

Blomquist, J., Bartolino, V., & Waldo, S. (2015). Price premiums for providing eco-labelled seafood: Evidence from msc-certified cod in sweden. *Journal of agricultural economics*, *66*(3), 690–704.

Bonroy, O., & Constantatos, C. (2008). On the use of labels in credence goods markets. *Journal of Regulatory Economics*, *33*(3), 237–252.

Cho, I.-K., & Kreps, D. M. (1987). Signaling games and stable equilibria. *The Quarterly Journal of Economics*, *102*(2), 179–221.

Daughety, A. F., & Reinganum, J. F. (2008). Imperfect competition and quality signalling. *The RAND Journal of Economics*, *39*(1), 163–183.

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

Hamilton, S. F., & Zilberman, D. (2006). Green markets, eco-certification, and equilibrium fraud. *Journal of Environmental Economics and Management*, *52*(3), 627–644.

Ibanez, L., & Grolleau, G. (2008). Can ecolabeling schemes preserve the environment? *Environmental and Resource Economics*, *40*(2), 233–249.

Jacquet, J., Pauly, D., Ainley, D., Holt, S., Dayton, P., & Jackson, J. (2010). Seafood stewardship in crisis. *Nature*, *467*(7311), 28–29.

Mahenc, P. (2007). Are green products over-priced? *Environmental and Resource Economics*, *38*(4), 461–473.

Mas-Colell, A., Whinston, M. D., Green, J. R., et al. (1995). *Microeconomic theory* (Vol. 1). Oxford university press New York.

Mason, C. F. (2011). Eco-labeling and market equilibria with noisy certification tests. *Environmental and Resource Economics*, *48*(4), 537–560.

Milgrom, P., & Roberts, J. (1986). Price and advertising signals of product quality. *Journal of political economy*, *94*(4), 796–821.

Mussa, M., & Rosen, S. (1978). Monopoly and product quality. *Journal of Economic theory*, *18*(2), 301–317.

Shaked, A., & Sutton, J. (1982). Relaxing price competition through product differentiation. *The review of economic studies*, 3–13.

Washington, S., & Ababouch, L. (2011). *Private standards and certification in fisheries and aquaculture*. FAO Technical report 553. Rome, Italy, 2011.