Monitoring Eco-Labels:
You Can Have Too Much of a Good Thing

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Abstract

An increasing number of product labels is making environmental claims. Typically, these claims are non-verifiable to consumers, they represent a credence attribute of the product. The usual way to handle this problem is external monitoring of such labels. We consider a model where firms in a competitive market choose product quality and the intensity of monitoring. It is shown that all the firms producing the high quality credence good will choose the same level of monitoring, i.e., an industry standard will evolve. However, in a competitive equilibrium there will be more monitoring than is socially desirable.

Keywords: credence goods, labels, monitoring, product quality.

JEL-Classifications: L15, D82

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1 Introduction

Consumers of organically produced vegetables, a doctor's patients and a firm's creditors have something in common. Even after purchase, they are often unable to observe the quality of the product or service they paid for. They might have paid an inappropriately high price for the low quality they received. This unobservability of quality is a common problem inherent in the consumption of credence goods. Firms have an obvious incentive to offer low quality at a high price. Consumers will anticipate this behavior and not buy the product in the first place, at least not for the price a firm charges for high quality.

Nevertheless, if there is a positive probability of detecting "cheating" and if the customer-firm relation continues over time, then there might be stable equilibria where firms honestly produce high quality.

In the following we consider a market for credence goods with repeated interaction between customers and firms. The model suits well for a market of consumer goods where customers are not able to distinguish the high quality attributes from low quality ones. For instance, consumers cannot find out by look, taste etc., if vegetables were produced organically, if tuna was fished dolphin-friendly or if animals were held in their natural environment.

As mentioned above, we have to include a positive probability of detecting wrongly labelled low quality products, otherwise no equilibrium exists. We can think of this probability as representing the level of monitoring through private or governmental agencies, consumer protection organizations etc.

An increasingly popular way to make this monitoring visible - and credible - to consumers is by means of third-party labels. All over Europe, the number of labels targeted at consumers has increased a lot during the last few years.[1] Many of these make environmental claims, mostly unverifiable for consumers. As an example, in Switzerland, there are several labels claiming that vegetables were produced organically. Some of these labels are third-party labels, some are firm-specific. But in every case, the monitoring is done externally. The creators of such a label are virtually free - up to a minimal legal standard - to define what "organically produced" means. Thus, they have a means to influence the probability that a product is discovered to be produced "non-organically". This aspect is analyzed in the model when we allow firms to choose the probability of detecting wrongly labelled products. The model results in all firms in the market choosing the same probability. And in fact, the different Swiss labels claiming organic production impose almost exactly the same conditions under which a product is considered "organic".

This structure of a market for credence goods where firms signal product quality by means of such product labels is the basis for our analysis. In a first step we will derive the conditions for an equilibrium with high quality production to exist. We shall see that price must be above marginal production cost in order to give firms an incentive not to deviate to low quality. Then, in addition to firms choosing the product's price, we let the level of monitoring be a firm's second choice variable to signal quality. We show that under unregulated competition, firms will choose a monitoring level which lies above the socially optimal level.

An early analysis of self-enforcing agreements is given by Telser [1980]. The general idea is that even without enforceable contracts, people will hold to an agreement if long run utility, arising from the ongoing relation, is higher than short run gains from defecting. For the case of experience goods, Shapiro

[1]For an illustration, see for example Thøgersen [2000].

[1983] shows that if firms obtain a reputation premium they are willing to produce high quality.

Klein and Leffler's [1981] analysis leads to similar conclusions. They examine the case where a number of identical firms can offer experience goods of different qualities. Production costs increase with quality. In each period consumers decide whether to buy the product or not. Since they buy experience goods, they do not know the true quality before consumption. If consumers detect that they have been cheated, meaning that they received lower quality than they paid for, they do not buy from the firm anymore. Klein and Leffler argue that no competitive equilibrium exists where firms offer more than minimum quality and the price for higher quality equals the respective production costs. Profit-maximizing firms prefer the one-time positive profit from offering low quality at a high price to receiving an ongoing stream of zero-profits accruing if price equals production costs. Consumers anticipate this behavior and are not willing to pay the high-quality price in the first place. If there exists an equilibrium, then it must entail price above marginal costs to give firms an incentive not to cheat in the short run.

The underlying model is similar to Klein and Leffler's. Major differences are the analysis of credence goods and the introduction of monitoring, exogenously given, resp., endogenously chosen by the firms.

The paper is structured as follows: section 2 introduces the model. Sections 3 and 4 analyze the cases for prices equal to, resp., higher than marginal production costs. In section 5, the choice of the monitoring level is endogenized, while the welfare analysis is in section 6. Section 7 concludes.

2 The Model

We consider a credence good market. The products can either have the quality desired by consumers or not, i.e., the product can be of high or low quality. Production costs c per unit of the high quality product are assumed to be constant and the same for all firms. Production costs for low quality are normalized to zero.[2] Consumers have different valuations for the high credence good quality with a maximum valuation H per unit of high quality product, with $H > c$.[3] These different valuations are represented by a downward sloping aggregate demand curve $D(p)$. Consumers' valuation of low quality products is normalized to zero.

The supply side of the market is characterized by a number of firms engaging in (Bertrand) price competition. Since product quality is not directly observable, firms have the possibility to indicate high quality by labelling their products. If there is no possibility to detect a wrongly labelled product, then firms have an incentive to cheat by putting labels on low quality products. Thus, consumers are not willing to buy the labelled goods and no equilibrium with high quality production exists.

Therefore, let us assume that a low quality product bearing a high quality label is detected with a probability q, where $0 < q < 1$. This can happen through watchdog agencies, information leaks, etc. Initially, this probability is given exogenously. Later on, we will endogenize q as a firm's choice variable.

Denote the price for a labelled product by P_H. For a simpler notation we will assume that each firm in the market only produces a single product per

[2] Thus, c is the incremental cost per unit to produce high quality.

[3] Therefore, if the price for one unit of the good is equal to marginal cost, there is always a positive demand for the good.

period. This assumption does not change the results. The multiproduct case is discussed in the appendix.

If a firm is discovered offering low quality products under a high quality label, the firm will not receive the price for high quality products.[4] Furthermore, consumers will not buy high quality labelled products from this firm anymore in the future.

The production decision takes place in every period. Firms are confronted with an infinite horizon, resp., with a positive probability that the interaction goes on after any period. Future cash flows are discounted by a factor δ, with $1 > \delta > 0$. The discount factor is assumed to be the same for all firms in the market. An increase in δ, which means future revenues become more valuable, can be interpreted as an increased frequency of interaction between firm and customer.[5]

In the next section we analyze the typical outcome of a competitive market with price being equal to marginal costs. As in Klein and Leffler, there does not exist an equilibrium where firms produce high quality goods and price equals marginal costs.

3 No Competitive Equilibrium with Marginal Cost Pricing and High Quality Production

In any period t a firm does not cheat if

[4] Or, if detection happens after the price has been paid, the firm has to restitute P_H for not having delivered the promised quality.

[5] Alternatively, δ may incorporate the possibility that a customer-firm relation ends at some point in time.

$$P_H - c + \delta V \geq (1-q)P_H + (1-q)\delta V$$

where V is the present value of following the optimal strategy for one product, starting from period $t+1$. The optimal strategy at period $t+1$, given that the firm did not leave the market at t,[6] is independent of today's choice. Once production took place and low quality products with wrong labels were not detected, a firm's situation at the beginning of the next period is the same as if it had produced high quality.[7]
Solving for the detection probability q and putting $P_H = c$ leads to

$$q \geq \frac{c}{P_H + \delta V} = \frac{c}{c + \delta V}. \tag{1}$$

From condition (1) we see that a competitive equilibrium with no cheating in period t only exists if $V > 0$, given that $q < 1$ and $\delta > 0$. The present value in the next period, V, is only positive if at least once in the future the optimal strategy implies cheating.[8] Note that this is one fundamental difference to the model of Klein and Leffler. Considering credence goods, a strategy can impose cheating without necessarily ending the game. In the period where cheating occurs, the expected profit per unit is $(1-q)P_H$. If no cheating ever occurs, V is equal to zero.

Now let us assume the optimal strategy at t implies cheating for the first time at period $t+j$. Since the firm never cheats before $t+j$ it is sure that

[6]If dishonest behavior was detected, consumers will not buy labelled products of this firm anymore.

[7]For this, we assume that consumer trust is not a function of a firm's age.

[8]Meaning that the firm receives the price P_H without having paid the production costs for high quality.

this point of the game is reached, i.e., cheating at $t + j$ must lie on the equilibrium path. Therefore, in a subgame-perfect equilibrium it must be optimal to play "cheating" at period $t+j$ not only looking ahead from t, but also when actually called to play at period $t + j$. But if the actual period is $t + j$ and cheating is optimal, then it is not possible that "not cheating" was the optimal strategy at t. This is because the firm's optimizing problem looks exactly the same at every period, given that it is considering an infinite horizon.

Thus, if $P_H = c$, "not cheating", i.e., producing high quality, at period t cannot be the optimal strategy. Since the situation is the same at every period, this is true for all periods. Consumers anticipate that firms never offer high quality and will not buy the product in the first place. This leads us to the following proposition.

Proposition 1 *In our market for credence goods no equilibrium exists where firms produce high quality and price equals marginal cost. This is true even if there is a positive probability of detecting dishonest firm behavior.*

At least some consumers value high quality products more than their production costs, since $H > c$. These consumers rather pay a price P_H above marginal production costs c to get the high quality credence good than buying low quality. In fact, one can show that there may exist equilibria where firms produce high quality and consumers pay $P_H > c$.

4 Equilibrium with Prices Above Marginal Cost and High Quality Production

Having shown that no equilibrium with $P_H = c$ exists, we will now analyze the case where firms receive a premium[9] for the production of high quality goods. Recall that some consumers have an incentive to pay a price up to H.

Again, the condition for a firm to prefer producing high quality in a given period is

$$P_H - c + \delta V \geq (1-q)P_H + (1-q)\delta V. \tag{2}$$

The present value per unit of the good, if a firm never cheats, is equal to $(P_H - c)/(1-\delta)$.[10] From condition (2) we can derive the minimum detection probability necessary to support an equilibrium where firms behave honestly. For this, it has to be the case that

$$q \geq \frac{c}{P_H^* + \delta V^*}$$

where P_H^* is the equilibrium price for high quality and V^* is the present value of always producing high quality starting from period $t+1$, i.e., $V^* = (P_H^* - c)/(1-\delta)$. Therefore, to support an equilibrium with no cheating, the probability of detection must satisfy the following condition:

$$q \geq \frac{c(1-\delta)}{P_H^* - \delta c} \tag{3}$$

[9]Meaning that price lies above marginal cost.

[10]Remember that the possibility that a product is not produced anymore in the future is incorporated in δ.

Call q^* the detection probability satisfying condition (3) with equality. Let us check how q^* changes with the other parameters.

Minimum detection probability related to other parameters

(i) Changes in equilibrium price:

$$\frac{\partial q^*}{\partial P_H^*} = -\frac{c(1-\delta)}{(P_H^* - \delta c)^2} < 0$$

The higher is the equilibrium price that firms receive for high quality all else equal, the higher is the profit they make now and in the future. And the higher are possible future profits the smaller are firms' incentives to cheat and thereby risking those profits. Therefore, the detection probability can be lower to still guarantee high quality production.

(ii) Changes in discount rate:

$$\frac{\partial q^*}{\partial \delta} = -\frac{c(P_H^* - c)}{(P_H^* - \delta c)^2} < 0$$

given that $P_H^* > c$. A higher discount rate means that firms put higher value to future profits. Thus, they have less incentive to risk those future profits by cheating. Again, this leads to a lower minimum detection probability to support the equilibrium with high quality production.

(iii) Changes in marginal cost:

$$\frac{\partial q^*}{\partial c} = \frac{P_H^*(1-\delta)}{(P_H^* - \delta c)^2} > 0$$

The higher marginal cost the lower are actual and future profits. This increases the incentive to sell low quality at a high price since the value at risk is lower. Therefore, minimum detection probability has to increase to support high quality production.

5 Choice of the Detection Probability is endogenized

If condition (3) is satisfied, firms will produce high quality and receive a premium $P_H^* - c > 0$ per unit sold.

If firms make positive profits and there is free entry into the market, then new entrants will be attracted. Normally, this will lead to the competitive outcome that price equals marginal costs, i.e., $P_H^* = c$, which cannot be an equilibrium as shown above. However, some consumers are always willing to pay a surplus in order to support an equilibrium with high quality production.[11] Under these conditions there is no price that supports an equilibrium where no party wants to deviate.

Klein and Leffler face a similar situation analyzing contractual performance with experience goods. They suggest the introduction of firm-specific, non-salvageable investments to impose zero profits and thus support an equilibrium with prices above marginal costs. We will apply the basic intuition of this idea for the underlying analysis.

Up to now we did not further specify the nature of the probability of detection q. In the following, q represents the intensity of external quality control, which a firm can influence by investing in monitoring. Assume that monitoring is costly and the higher the probability of detection, the higher is the cost. This captures the fact that a higher probability of detection

[11] Since maximum valuation H of high quality is larger than c.

requires more intense and costly monitoring, like a steady inspection of a firm's production facilities or a greater number of product tests.

Without any monitoring the probability of detection is equal to zero. Consumers will not pay any premium and firms will not produce high quality.

To be able to sell high quality products for the respective price, potential suppliers of high quality credence goods have to credibly differentiate themselves from low-quality producers. Firms thus have to invest in monitoring in order to increase q and support an equilibrium where they get a surplus for high quality products.

If this investment in monitoring is unobservable as is product quality, it will not be credible for consumers. Therefore, the investment must be made visible. A possible way to do so is to hire experts certifying a firm's products' quality.[12] This is often done in a standardized way by paying license fees to a monitoring institution to get the right to put this institution's quality label on a firm's product.

Let monitoring costs per unit be represented by a function $g(q)$, with $g(0) = 0$ and $g'(q) > 0$.[13] These costs are paid at the beginning of every period. If a firm does not get the label, it will not be able to sell its products at the high quality price. Paying monitoring costs is thus like an entry cost to the market of high quality credence goods. This cost is not salvageable, i.e., it is sunk.

A firm will enter the market for high quality credence goods and produce

[12]For an analysis of expert services refer to Emons[1997 and 2001].

[13]Testing two tons of corn might involve some economies of scale relative to testing one ton. But on the other hand, there are more possibilities to cheat by including low quality during the production process, e.g., because a greater number of farms is involved etc. This requires to keep a closer eye to the production and distribution of these goods. Altogether, it seems reasonable to assume constant per unit costs $g(q)$.

high quality if

$$P_H - c - g(q) + \delta V \geq (1-q)P_H - g(q) + (1-q)\delta V \geq 0.$$

In a competitive equilibrium with high quality production, two conditions have to be satisfied:

$$q \geq \frac{c(1-\delta)}{P_H^* - \delta c} \tag{4}$$

$$g(q) = P_H^* - c \tag{5}$$

Condition (4) is the "no-cheating" condition whereas equation (5) is the zero-profit condition. In principle q, the level of external monitoring, could be different across different firms. But if (4) is satisfied with strict inequality, firms could lower the level of detection probability and still credibly sell at a high quality price. This would lower monitoring costs. By the induced positive profits, new entrants would be attracted and equilibrium price lowered. This, on the other hand, increases the minimum level of detection probability since the profit margin eroded and potential future profits are less of a bond for honest behavior. Therefore, both of the above conditions have to be satisfied with equality in equilibrium, i.e., $q = q^*$. This is true for all firms in the market.

Proposition 2 *Even though firms can individually choose the monitoring intensity, an industry standard will evolve. In equilibrium, all firms in the market will face the same level of monitoring, represented by the probability of detecting wrong labels.*

Solving (5) for q and inserting the result into (4) yields the condition for a high quality equilibrium:

$$g^{-1}(P_H^* - c) = \frac{c(1-\delta)}{P_H^* - \delta c} := f(P_H) \qquad (6)$$

At $P_H = c$ condition (6) is evidently not satisfied since $g^{-1}(0) = 0$ and the term on the right side is strictly positive. Increasing P_H increases $g^{-1}(\cdot)$ and decreases the term on the right side. Thus, there exists at least one price for high quality credence goods P_H^* that satisfies condition (6) as long as

$$g^{-1}(H - c) \geq \frac{c(1-\delta)}{H - \delta c}.$$

An equilibrium with high quality production therefore exists if

$$1 > g^{-1}(H - c) \geq \frac{c(1-\delta)}{H - \delta c}. \qquad (7)$$

If condition (7) is satisfied we find unique values for q^* and P_H^* that satisfy the equilibrium condition (6) for any strictly increasing monitoring cost function $g(q)$. These findings are summarized in proposition 3.

Proposition 3 *If condition (7) is satisfied, then there exist combinations of price and detection probability that constitute an equilibrium with high quality production. Given that monitoring costs are strictly increasing in the detection probability q, this equilibrium is unique.*

Three equilibria for different cost functions, represented as dotted lines, are depicted in figure 1.

[insert figure 1 about here]

From figure 1 we see the relation between the form of the monitoring cost function $g(q)$ and the equilibrium values q^* and P_H^*. If monitoring costs rise only relatively little in order to guarantee a higher detection probability,[14] firms will choose a high level of external monitoring to convince customers about the quality of their products. On the other hand, if the cost increase in monitoring is relatively strong, firms rather increase prices as a bond for honest behavior.

6 Welfare Considerations

If information about product quality was symmetric, price would equal marginal cost and demand would be such that consumer surplus of the marginal consumer equals zero. As shown above, this situation is not an equilibrium if product quality is not observable.

In the last section we derived the conditions for the existence of an equilibrium for a market with high quality credence goods. We found that consumers' trust in non-observable product quality is based on a combination of a price premium and an endogenously determined level of monitoring.

Monitoring is needed to support an equilibrium with high quality production. Given that there is no value added at all, it is a waste of resources. From this point of view, the level of monitoring should be kept as low as possible. As we saw in the last section there is a negative relation between the equilibrium level of monitoring q and the premium $P_H - c$. Therefore, decreasing q means increasing P_H. But the higher the equilibrium price the higher will be the deadweight loss due to a decreasing consumer surplus. This loss is illustrated as the shaded area in figure 2.

[14] In this case the inverse of $g(q)$ quickly increases.

[insert figure 2 about here]

From a social point of view there is a trade off between a higher level of monitoring, inducing higher cost, and a higher equilibrium price, inducing a lower consumer surplus. In this section we want to analyze whether the market outcome corresponds to the socially optimal level of monitoring. As we will see, this is generally not the case. In fact, there is too much monitoring in a competitive credence good market.

The socially optimal level of monitoring, represented by the detection probability, minimizes the society's cost of supporting the high quality equilibrium. These cost arises from two factors: direct monitoring cost and the loss in consumer surplus. These costs are minimized considering that the "no-cheating" condition (4) must still be satisfied. Otherwise, no equilibrium exists. The optimal value for q thus minimizes

$$D(P_H)g(q) + \int_{D(P_H)}^{D(c)} D^{-1}(x)dx - cD(c) + cD(P_H) \tag{8}$$

$$s.t. \qquad P_H = \delta c + \frac{c(1-\delta)}{q}$$

where the first term in the objective function represents society's total monitoring cost. The other part of the objective function is the deadweight loss due to price being above marginal costs, represented by the shaded area in figure 2. Inserting the expression for P_H into the objective function and using Leibniz' rule for differentiating the integral, we find the following first order condition:

$$\frac{\partial D(P_H^{'})}{\partial q} g(q') + D(P_H^{'}) \frac{\partial g(q')}{\partial q} - D^{-1}(D(P_H^{'})) \frac{\partial D(P_H^{'})}{\partial q} + c \frac{\partial D(P_H^{'})}{\partial q} = 0,$$

where $P_H{}'$ and q' represent the socially optimal values for price and detection probability. The above expression can be simplified to the following:

$$\frac{\partial D(P_H^{'})}{\partial q}(g(q') + c - P_H^{'}) + D(P_H^{'})\frac{\partial g(q)}{\partial q} = 0. \tag{9}$$

Given our assumptions, both partial derivatives in equation (9) are strictly positive. So is $D(P_H^{'})$ in an equilibrium with positive demand for the high quality credence good. In this case, equation (9) implies that

$$g(q') < P_H^{'} - c. \tag{10}$$

Comparing this to the equilibrium condition, $g(q^*) = P_H^* - c$, it immediately follows that

$$q' < q^*.$$

Thus, the level of monitoring, measured by the detection probability, that results in a competitive market is higher than the socially optimal value. From condition (9) we see why this is the case. Under price competition, monitoring costs per unit equal the premium per product, i.e., $g(q^*) = P_H^* - c$. From a social point of view this only offsets cost and benefit from an increase in demand due to more intensive monitoring. What is not considered is the increase in total monitoring costs given the equilibrium demand, $D(P_H)\partial g(q)/\partial q$.

Under price competition with free market entry, condition (10) is an unstable situation inducing entry until the premium equals the cost. Thus, competition drives up the level of monitoring higher than is socially desirable. This is summarized in proposition 4.

Proposition 4 *If demand for the high quality credence good is strictly decreasing in price and monitoring costs are strictly increasing in the detection probability, then price competition results in a level of monitoring higher than socially efficient.*

Notice that in a market with imperfect competition, including the case where entry is not free, a price above marginal cost may be maintained. In such a surrounding, condition (9) could be satisfied even in a market outcome. This allows the thought that, from a social point of view, imperfect competition might even be desirable in a market for credence goods.

7 Conclusion

We consider a market for credence goods with a competitive supply side and an infinite horizon. Firms can choose to offer high or low quality products which cannot be observed by the consumers even after consumption. To attain an equilibrium with positive demand for high quality products, we have to include the possibility that dishonest behavior is detected. This can happen through hired experts, monitoring institutions, competitors etc.

Assuming that it is more costly to produce high quality, firms will always have an incentive to deviate from honest behavior if price equals marginal cost. This means, firms prefer a positive short run gain from offering low quality at a high price to receiving an ongoing stream of zero profits. Since consumers anticipate this behavior they will not be willing to pay the high price in the first place. Thus, no equilibrium with high quality production and price equal to marginal cost exists.

However, if future expected profits are positive, firms will have an incentive to behave honestly, i.e., to produce high quality when claiming to do so.

If this premium is high enough, they will not risk future profits by cheating in the short run. Endogenizing q, we analyze the conditions for existence and uniqueness of an equilibrium with high quality products.

Since the only reason for monitoring in this model is to support the high quality equilibrium, monitoring is a waste of resources compared to the full information case. Thus, monitoring costs should be kept as low as possible. However, due to the negative relation between the level of monitoring and the high quality premium, this means to increase price. But by increasing price, consumer surplus is reduced. The socially efficient level of monitoring thus minimizes the sum of monitoring costs and deadweight loss due to price being above marginal cost. We find that under very general conditions, the level of monitoring resulting in a competitive outcome lies above the socially optimal level.

Appendix

Firms may produce more than one unit per period

Firms producing more than one unit of the good could play a mixed strategy by producing both high and low quality while selling both for P_H. We assume that consumers react to detected cheating by not buying high quality labelled products from this firm anymore.[15] Consumers extend the experience made with one product to all of this firm's products. If wrongly labelled low quality products are detected, a firm loses the revenue from all its products.[16] Given consumers' behavior the firm's optimal decision is to produce either high or low quality, but not both. This observation is formulated as Lemma 1.

Lemma 1 *If consumers extend bad experiences with one product to all of a firm's products by not buying from this firm anymore, the firm's profit-maximizing choice is to produce either only good quality or only bad quality.*

Proof of Lemma 1

If q is the probability that a single wrong label is detected, then the risk of at least one such label being detected is $1-(1-q)^{n(1-s)}$, where n is the total number of a firm's products and s is the fraction of high quality goods. V is the present value of profits coming from one unit of the product, following the optimal strategy from period $t+1$ onward. In each period, a firm maximizes

[15] It is actually enough to assume that consumers reduce the price they are willing to pay for all other product units offered by the same firm by some positive amount.

[16] In a recent case in Switzerland, a large supplier of organically produced goods had to withdraw the whole lot of one product type after a higher than allowed fraction of genetically modified corn was detected and sell it at the low quality price. In terms of the underlying model, the firm invested c but could afterwards not cash in the high quality price P_H.

expected profits, given by

$$\pi^e = n(1-q)^{n(1-s)}[P_H + \delta V] - nsc.$$

The second derivative of expected profits is

$$\frac{\partial^2 \pi^e}{\partial s^2} = n^3(\ln(1-q))^2(1-q)^{n(1-s)}[P_H + \delta V] > 0.$$

Expected profits are strictly convex in the fraction of high quality products. Therefore, the profit-maximizing choice for s is either 0 or 1, meaning that a firm only produces high quality or low quality, but no mixture. Q.E.D.

For a more detailed analysis of this question, see Liebi [2002]. There, a monopolist chooses quality if consumers react to cheating by lowering the price on all other goods. As shown there, the monopolist's profit-maximizing choice is either to produce only high or only low quality but no mixture of both.

For an analysis of product perceptions under the same brand influencing each other - the problem of brand extension or umbrella branding - see Wernerfelt [1988], Choi [1998] and Cabral [2000]. Also, in a recent paper, Andersson [2002] shows that there might be economies of scope in carrying a reputation, making reputation pooling worthwhile.

Since firms do not mix qualities, i.e., quality decision is the same for all the goods of one firm, we can state the firm's problem as if it individually decides for each single good. Therefore we can abstract from the decision of optimal firm size with respect to the number of products.

Given the above specified consumer reaction, an important parameter is the total risk of detection in the case of producing low quality. This value evidently depends on the number of goods and is calculated as $1-(1-q)^n$. Let $d(n)$ represent this risk of detection.

The present value per good if a firm never cheats is equal to $(P_H - c)/(1-\delta)$. The discount factor δ also incorporates the possibility that a product is not produced in the future anymore. Therefore, the condition that a firm prefers producing high quality in a given period is

$$P_H - c + \delta V \geq (1 - d(n))P_H + (1 - d(n))\delta V.$$

This is analogous to condition (2). From here, the analysis is the same as in the main part of the paper with the total risk of detection $d(n)$ replacing the single product probability q. All the propositions remain valid. In the case of proposition 2 this means that the level of monitoring, represented by the total risk of detection, is the same for all firms in the market. This is true, even if they differ in terms of the number of products they produce. In this case, a larger number of products combines with a smaller detection probability per product.

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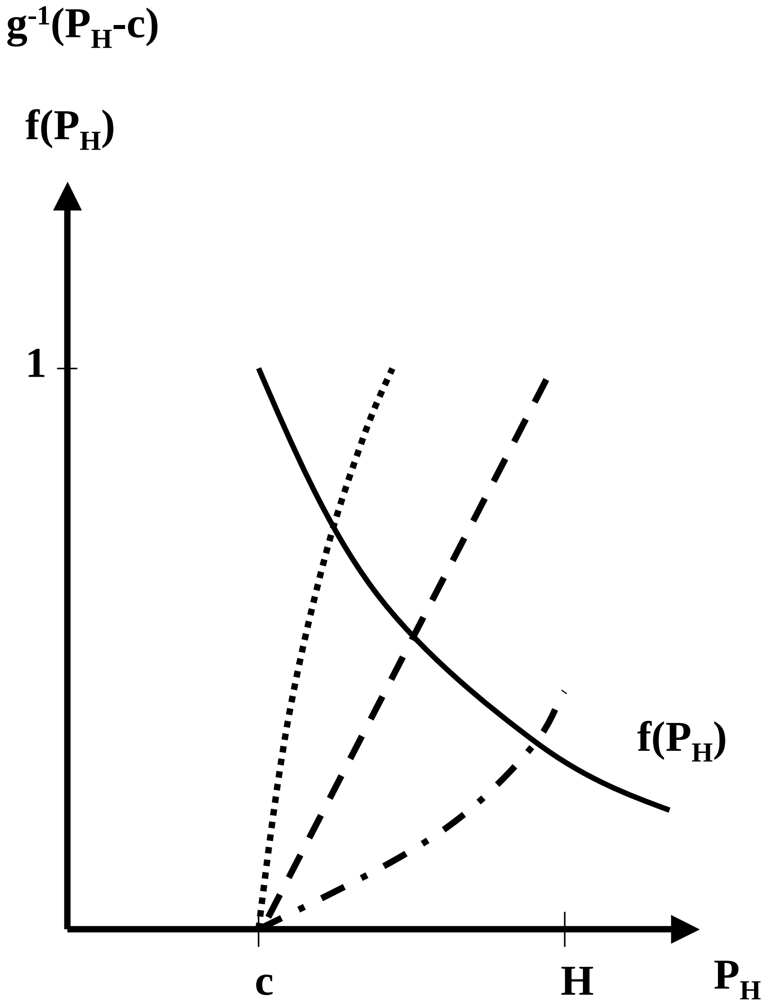

Figure 1: Equilibrium for three different monitoring cost functions

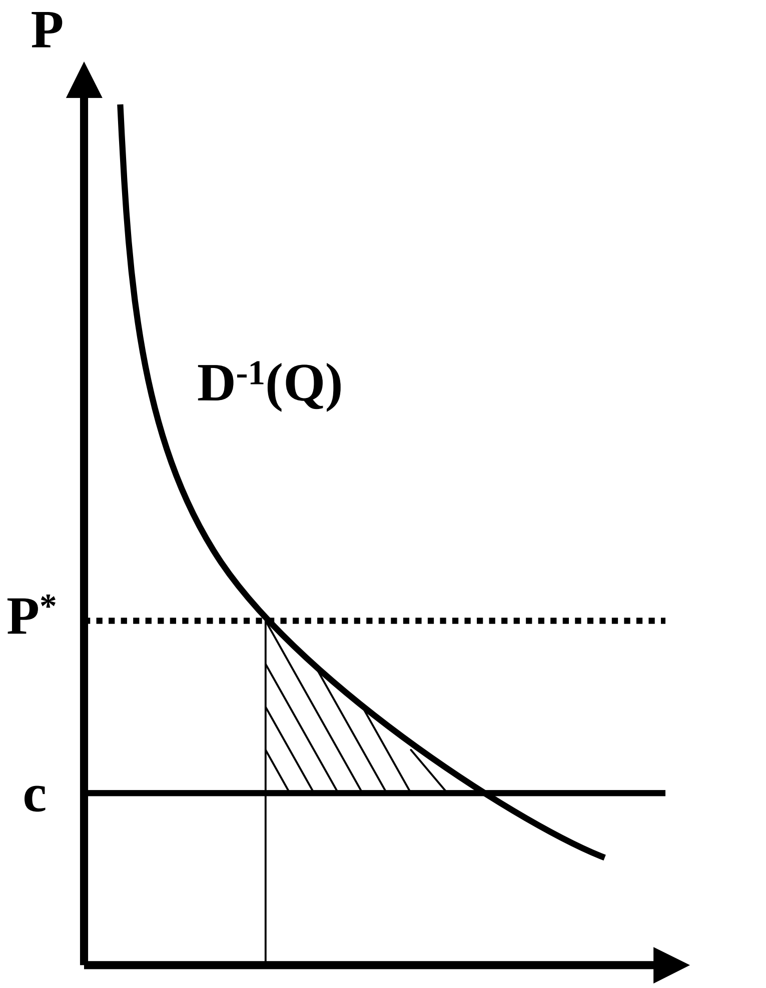

Figure 2: Demand function and deadweight loss