Quality Disclosure in a Supply Chain - Unraveling from the Top and the Bottom

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Abstract

For many products, consumers can not assess the quality in advance and a firm may rely on certification or disclosure to communicate the quality of its product to consumers. The standard unraveling result in such a setup states that a firm will disclose its quality for all but the lowest realizations. The reasoning is, that consumers 'pool' all realizations for which a firm does not disclose the quality yielding incentives to defect from this pooling whenever the realized quality is high.

The objective of this paper is to show that this unraveling result is fundamentally changed if instead of looking at a firm that directly sells its product to consumers we model a manufacturer who indirectly sells through a retailer. If the manufacturer is given the (costly) opportunity to disclose the quality of his product, he will do so for all but some intermediate quality levels.

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1 Introduction

Purchase decisions of consumers are often characterized by uncertainty about many aspects of the good they are considering and much of this uncertainty vanishes only when consumers have consumed the product in question. This is especially the case for the quality of a product. At the same time, it may well be that the producer of the good has superior knowledge about his product's quality. Such products are typically called experience goods (Nelson, 1970) and they have produced a large amount of literature. In particular the literature explores how information about the quality can credibly be transmitted from the producer to consumers in order to facilitate and influence their purchasing decision.

The literature is roughly separated into two distinct areas, one of information disclosure, and one of information signaling. Whereas the disclosure literature assumes that firms can choose between truthfully revealing the quality of their product or remain silent, the signaling literature models scenarios where consumers can rationally infer a good's quality from observed behavior of the firm. Disclosure can be understood as having a third party firm audition and certify the quality of an experience good. Signaling is mostly modeled as happening through the price, but may as well happen through costly advertising (a seminal paper in this regard is Milgrom and Roberts, 1986).

The seminal papers on quality disclosure (Milgrom, 1981; Grossman, 1981) assume that disclosure is costless and that production costs of the experience good are independent of the quality level. In such a setting the producer of the good will choose to disclose the quality of his product for any quality level. This result can intuitively be understood by considering the manufacturer's incentives to disclose for different levels of product quality. Without any disclosure, consumers must expect the quality to be average, so that the manufacturer will certainly want to disclose the quality of his product whenever it has the highest possible value. Consumers anticipate these incentives of the manufacturer and when they do not observe the manufacturer disclosing the quality, they reason that the good can not be of the highest quality so that the expected quality if no disclosure is observed is now lower than before. This gives the manufacturer incentives to disclose the quality for lower quality levels which again leads consumers to expect an even lower quality if no disclosure is observed. With costless disclosure, this continues for any quality of the product and the sketched process is often called 'unraveling'. If disclosure is not costless the same logic applies, only that now the firm will not disclose the quality for the lowest levels, as the disclosure costs at some point outweigh the gain from disclosing (see for example Jovanovic, 1982; Viscusi, 1978).

Daughety and Reinganum (2008) were the first to combine the two strands of literature. In their model, firms can disclose their products quality at positive costs, but unlike in the classical literature on disclosure, the alternative to disclosing is not pooling of the qualities for which the firm does not disclose. Instead the firm chooses whether to communicate the quality of its product to consumers via disclosure or via signaling through the retail price, so that consumers

will in equilibrium know the quality of the good irrespectively of whether disclosure has taken place or not. Daughety and Reinganum show that there is a range of disclosure costs such that the firm chooses to reveal its quality via price-signaling for low quality levels and it chooses to disclose for relatively high quality levels. They emphasize that disclosure is less frequent than with models were the firm has no opportunity of revealing the quality by signaling.

In all the aforementioned papers, the firm that produces the good is also the one which is selling it to consumers. This paper builds on the idea of Daughety and Reinganum (2008), namely that a firm may choose between using disclosure and signaling via the retail price to communicate its quality, and applies it to a manufacturer-retailer model, where the firm producing the good is not the one selling it to consumers. Both firms in the setup are monopolists and the occurrence of a double marginalization effect or 'problem' is well known in such a context and was already anticipated by Cournot (1863) and formally derived in Spengler (1950). The double-marginalization effect states that in such a setup the retail price is even higher than the one where a monopolist directly sells the good to consumers. This is the case as the monopolistic retailer now also exhibits market power and thus will charge an additional markup thereby inflating the retail price.

It will be shown that in this setup, and contrary to the existing literature, the manufacturer will decide to disclose the quality of his product for all but some intermediary levels. This will be seen to be profitable for him as he can use his disclosure decision to weaken the problem of double marginalization.

One could ask whether a firm in reality would disclose or certify low quality of its product. Interestingly this is precisely what a German manufacturer of mattresses did recently. The German testing institute 'Stiftung Warentest' (which translates as 'foundation for product test' and is similar to consumer reports in the United States) examined mattresses of five start-up firms.[1] The five mattresses received grades from 2.3 to 4.7 (where 1 is the best and equals the American 'A' and the worst grade, 5 equals 'F') and surprisingly one of the firms, called 'muun', with one of the worst test grades, namely 4.1, advertised this grade in a marketing campaign, calling their mattress the 'most sufficient' (sufficient describes the grade 4 in German schools).[2] The only other firm which advertised the result of the test, was the winner with the highest grade.[3] While the goal of muun seemingly was to put the test results into perspective, it is nevertheless interesting that only one of the worst and the test winner used the test results in their advertising. It might also be well the case that potential consumers only got to the know the test results because of the advertising campaign, and that they wouldn't have found out about it otherwise.

Clearly, only the test winner and one of the firms with the worst test results advertising or disclosing the test results, is not compatible with any of the disclosure patterns of the previous literature, but as we will see it is more in line with the results of this paper.

[1] See for example (in German) `http://www.welt.de/icon/moebel/article158957032/Wie-ein-Matratzen-Start-Up-Stiftung-Warentest-vorfuehrt.html` (last accessed November 28, 2016)

[2] See (in German) `https://muun.co/stiftungwarentest` (last accessed November 28, 2016)

[3] See (in German) `https://www.home24.de/smood-shop/` (last accessed November 28, 2016)

The remainder of this article is structured as follows: The next section presents the model. Optimal price setting for a setting with full information and for one with asymmetric information are derived in section 3. In section 4, these results are compared order to assess disclosure incentives in the model. The closing section concludes.

2 Model Setup

The model resembles the one from the companion paper Conze (2016) with the main difference being that the focus is on disclosure instead of on cheap-talk.

The model features two firms (both "he"), a manufacturer (M) and a retailer (R). M produces an experience good of random quality q with q being distributed according to a distribution function $F(q)$ with full support on the interval $Q = [0, \overline{q}]$. The manufacturer has to pay $c(q)$ to produce one unit of the good, higher quality goods are more costly to produce, so we impose $c'(q) > 0$. Additionally we normalize $c(0) = 0$. After the production, M sells the good(s) to the retailer, who observes q, at the wholesale price w. The retailer then serves the customers at the retail price p. Besides paying the wholesale price w, R does not incur any costs when making sales.

At the same time M sets his wholesale price, he can decide whether to disclose the quality level or not. Disclosing, which comes at costs $d > 0$ for the manufacturer, leads to the realization of q being public knowledge. $D \in \{0, 1\}$ denotes M's disclosure decision, with $D = 1$ if M disclosed the quality, and $D = 0$ otherwise. Disclosure and the costs it bears can be seen as a costly form of certification by a third party (not modeled here) like in the example given above, so that the manufacturer has no possibility to lie, he can only choose to reveal the quality of his product truthfully or to remain silent.

On the consumer side there are two types of consumers with unit demand, considering to purchase the good. Consumers (referred to as "she"), are either of a low-type ($i = \ell$) or of a high-type ($i = h$). There are m consumers in total, n_h of which are high-types and n_ℓ are low-types. For convenience, we normalize $n_\ell = 1$. The high-types utility from consumption of one unit of the good is always weakly higher than the utility of the low-type when consuming a unit of the same quality. More precisely, consuming one unit of the good leads to the following ex-post utility:

$$v_i(q) = k + \theta_i q$$

where $\theta_i \in \{\theta_\ell, \theta_h\}$ is the consumers type with $0 < m\theta_\ell < n_h\theta_h$.

Consumers may not know the quality of the good at the time they consider purchasing it, so they have to form beliefs, mapping the available information into an assessment of the good's quality. By construction of the demand, any consumer only cares about the expected value of the quality so that we can reduce the belief. Formally, let $\beta : (p, D) \to \Delta Q$ be a consumer's belief and let $\mu(p, D) = E_{\beta(p,D)}(q)$ be the expected quality derived from this belief. A consumer purchases the good whenever her expected utility is at least as large as the charged retail price, thus a

consumer of type θ_i then purchases the good whenever

$$E(u_i(q)) = k + \theta_i \mu(p, D) \geq p. \tag{1}$$

As the manufacturer has no possibility to lie, all consumers know the realized quality if M decided to disclose so that $\mu(p, D = 1) = q$ for any price p.

Perfect Bayesian Equilibrium will be the employed solution concept, which here means:

Requirement 1. *Firms maximize their profit given the other firm's and consumers' strategies. Consumers act optimally given the strategies of the firms and their beliefs μ.*

Requirement 2. *Consumers' beliefs are derived from the firms' strategies and Bayes' rule whenever possible.*

Regarding the relation of the different parameters, the condition $c(\overline{q}) \geq k - \overline{q}(n_h\theta_h - m\theta_\ell)$ will be imposed. It ensures that if consumers know that the quality is given by $\overline{q}$ the joint profits of the two firms are maximized with sales to the high-type consumers only and not by sales to all consumers. Additionally, we will assume that $k \geq n_h\theta_h E(q)$, which guarantees that the firms joint profits at a quality level of $q = 0$ if q were known, are higher than selling to all consumers with the prior expectation of the quality. The above condition ensures that there is some value $q' \in Q$, such that joint firm profits are maximized by selling to all consumers for lower values and by selling to high-type consumers only, for higher values of q. We will see in the next sections that this condition will allow for separation to take place.

3 Optimal Price Setting

We are interested in the manufacturer's incentives to disclose his quality to consumers, to this end we need to analyze the subgames starting with the manufacturer's decision to disclose or not to disclose. In the next step we can then compare the results in order to obtain M's optimal disclosure decision. In each case we will employ backwards induction logic, starting with characterizing the behavior of the consumers, then looking at R's optimal decision, given the consumer behavior and in the last step we analyze M's optimal strategy, given the behavior of all other agents.

We will begin with a subgame that started with the manufacturer disclosing q. Given that consumers (and by assumption, the retailer) know q after M decided to disclose, the following subgame is one of perfect information.

3.1 Full Information

With the consumers being perfectly informed about the quality q, a consumer of type θ_i will purchase the good whenever $v_i(q) = k + \theta_i q \geq p$. The retailer anticipates this consumer behavior and optimally chooses his retail price p. Clearly, for a fixed quality q, the demand is constant and

equal to m for all prices $p \leq p_\ell^D(q) := k + \theta_\ell q$, it equals n_h for prices p such that $p_\ell^D(q) < p \leq p_h^D(q) := k + \theta_h q$ and is zero for higher prices.

R will set the price that maximizes his profit $\pi_R^D(p)$, and if w is not prohibitively high, this is achieved by setting one of the prices $p_\ell^D(q)$ or $p_h^D(q)$. R will charge $p_\ell^D(q)$ if

$$\begin{aligned} & \pi_R^D(p_\ell^D(q)) = m(k + \theta_\ell q - w) \geq n_h(k + \theta_h q - w) = \pi_R^D(p_h^D(q)) \\ \Leftrightarrow \quad & w \leq w_\ell^D(q) := k + (m\theta_\ell - n_h\theta_h)q \end{aligned}$$

As the demand at R is a step function, the same is true for the quantities R demands from M, where R demands m units if $w \leq w_\ell^D(q)$, n_h units if $w_\ell^D(q) < w \leq p_h^D(q)$ and zero for higher wholesale prices. This implies that M can leave R with a profit of zero if the wholesale price is set to $w_h^D(q); = p_h^D(q)$.

Anticipating R's behavior, M optimally chooses between setting either of the wholesale prices $w_\ell^D(q)$ and $w_h^D(q)$. M is indifferent between $w_\ell^D(q)$ and $w_h^D(q)$ if

$$\begin{aligned} & \pi_M^D(w_\ell^D(q)) = m(k + (m\theta_\ell - n_h\theta_h) - c(q)) = n_h(k + \theta_h q - c(q)) = \pi_M^D(w_h^D(q)) \\ \Leftrightarrow \quad & c(q) = k + (m^2\theta_\ell - n_h(1+m)\theta_h)q \end{aligned}$$

By assumption, the two consumer groups differ enough so that $n_h\theta_h > m\theta_\ell$ and thus, this equation has a unique solution, the solution will be denoted by $\hat{q}^D$. For values of $q < \hat{q}^D$ ($q > \hat{q}^D$), M will set a price of w_ℓ^D (w_h^D).

The following summarizes the equilibrium in the game with full information:

Lemma 1. *In the game with full information, the equilibrium wholesale and retail pricing schemes are given as follows*

$$w = \begin{cases} w_\ell^D(q) = k + (m\theta_\ell - n_h\theta_h)q & \text{if} \quad q \leq \hat{q}^D \\ w_h^D(q) = p_h^D(q) = k + \theta_h q & \text{else} \end{cases}$$

$$p = \begin{cases} p_\ell^D(q) = k + \theta_\ell q & \text{if} \quad w \leq w_\ell^D(q) \\ p_h^D(q) = k + \theta_h q & \text{else} \end{cases}$$

The threshold $\hat{q}^D$ is defined by the following equation

$$c(\hat{q}^D) = k + (m^2\theta_\ell - n_h(1+m)\theta_h)\hat{q}^D$$

If $p = p_\ell^D(q)$ all consumers buy, at the higher price only the high types purchase the good.

3.2 Asymmetric Information

Let us next look at a situation where disclosure costs are prohibitively high, so that M will never find it profitable to disclose his products' quality. Much of the optimal behavior of firms and consumers is similar to the previous characterization, with the main difference being that instead of using the realized quality q as before, we now have to take into account the beliefs of consumers.

If Consumers do not know the quality of M's product, they purchase whenever their expected utility is positive. Fix a set of beliefs μ and, for $i \in \{\ell, h\}$, define a set of prices P_i, so that consumers of type i purchase the good for all prices $p \in P_i$. From equation (1) these sets are given by $P_i := \{p : p \leq k + \theta_i \mu(p, D = 0)\}$. Let $p_i(\mu(p_i, D))$ denote the maximal element of the set P_i, $p_i(\mu(p_i, D)) := \max P_i$. For ease of notation, let $\mu_i := \mu(p_i, D = 0)$, be the belief induced by the maximal prices consumers of type $i \in \{\ell, h\}$, are willing to pay. $p_i(\mu_i)$ thus gives the highest price for which consumers of type i are willing to purchase the product. As high-type consumers purchase the good whenever low-types do, it must be the case that $p_\ell(\mu_\ell) \leq p_h(\mu_h)$

Clearly, the demand the retailer faces, again is a step function and equal to m for all prices $p \leq p_\ell(\mu_\ell)$, it equals n_h for prices $p_\ell(\mu_\ell) < p \leq p_h(\mu_h)$ and is zero for higher prices.

The goal of the retailer is to maximize his profit $\pi_R(p)$, which, if w, the wholesale price charged by the manufacturer, is not prohibitively high, is achieved by a retail price of either $p_\ell(\mu_\ell)$ or $p_h(\mu_h)$. R will set a price of $p_\ell(\mu_\ell)$ if

$$\begin{aligned} & \pi_R(p_\ell) = m(k + \theta_\ell \mu_\ell - w) \geq n_h(k + \theta_h \mu_h - w) = \pi_R(p_h) \\ \Leftrightarrow \quad & w \leq w_\ell(\mu_\ell)^4 := k + m\theta_\ell \mu_\ell - n_h \theta_h \mu_h \end{aligned}$$

As was the case with full information, because the demand at R is a step-function, the same is true for the quantities R demands from M and R demands m units for $w \leq w_\ell(\mu_\ell)$, n_h units if $w_\ell(\mu_\ell) < w \leq p_h(\mu_h)$ and zero units for higher values of the wholesale price. Given the structure of the demand M faces, he can leave R with zero profit by setting $w = w_h(\mu_h) := p_h(\mu_h)$ and M's optimal wholesale price must again be either $w_\ell(\mu_\ell)$ or $w_h(\mu_h)$. M is indifferent between $w_\ell(\mu_\ell)$ and $w_h(\mu_h)$ if

$$\begin{aligned} & \pi_M(w_\ell) = m(k + m\theta_\ell \mu_\ell - n_h \theta_h \mu_h - c(q)) = n_h(k + \theta_h \mu_h - c(q)) = \pi_M(w_h) \\ \Leftrightarrow \quad & c(q) = k + m^2 \theta_\ell \mu_\ell - n_h(1 + m)\theta_h \mu_h \end{aligned} \tag{2}$$

As it can not be the case that no sales are made in equilibrium, at least one of the beliefs μ_ℓ and μ_h is on the equilibrium path. Depending on those beliefs μ_ℓ and μ_h, this equation may or may not have a solution. If the equation has a solution, it will be referred to as $\hat{q}$, and the

[4] Note that w_ℓ clearly depends on both beliefs μ_ℓ and μ_h, nevertheless we will in the following only use μ_ℓ as an argument, as the region where a wholesale price of w_ℓ is set defines the belief μ_ℓ.

properties of the cost function $c(q)$ imply that M must then prefer to set a wholesale price $w_\ell(\mu_\ell)$ for $q < \hat{q}$ and he will find it optimal to set $w_h(\mu_h)$ for $q > \hat{q}$.

Combining these observations, it is clear that, depending on the beliefs μ_ℓ and μ_h, three qualitatively different equilibria might emerge. Either we observe a pooling equilibrium where sales are only made to the low type consumers or a pooling equilibrium where only high type consumers buy, and the last possibility is given by a separating equilibrium constructed according to equation (1).

The three possibilities are summarized in the following lemma. For brevity, only the behavior on the equilibrium path is stated, off equilibrium behavior in each of the three equilibria is characterized by the above descriptions.

Lemma 2. *If disclosure costs are prohibitively high, depending on the beliefs of consumers μ_ℓ and μ_h, one of the following situations with stated wholesale and retail prices will emerge in equilibrium.*

1. *High type pooling equilibrium:*

$$w = w_h(E(q)) = p_h(E(q)) = k + \theta_h E(q)$$
$$p = p_h(E(q)) = k + \theta_h E(q)$$

2. *Low type pooling equilibrium:*

$$w = w_\ell(E(q)) = k + m\theta_\ell E(q) - n_h \theta_h \mu_h$$
$$p = p_\ell(E(q)) = k + \theta_\ell E(q)$$

3. *(Partly) separating equilibrium:*

$$w = \begin{cases} w_\ell\left(E(Q_\ell)\right) = k + m\theta_\ell E(Q_\ell) - n_h\theta_h E(Q_h) & \text{if} \quad q \leq \hat{q} \\ w_h\left(E(Q_h)\right) = p_h = k + \theta_h E(Q_h) & \text{else} \end{cases}$$
$$p = \begin{cases} p_\ell = k + \theta_\ell E(Q_\ell) & \text{if} \quad w = w_\ell \\ p_h = k + \theta_h E(Q_h) & \text{if} \quad w = w_h \end{cases}$$

   where $\hat{q}$ is defined by equation (2) and, $\mu_i = E(Q_i) := E(q|q \in Q_i)$ for $i \in \{\ell, h\}$ with $Q_\ell = [0, \hat{q}]$ and $Q_h = (\hat{q}, \overline{q}]$.

In any equilibrium, all consumers buy if $p = p_\ell$, at the higher price of $p = p_h$ only the high types purchase the good.

4 Incentives to Disclose

If we want to investigate the manufacturer's incentives to disclose his quality, we need to compare his profit in a subgame after disclosure with his profit without disclosure. With sufficiently small disclosure costs, it is clear that in equilibrium, there must be realizations of q for which M will prefer to disclose the quality and induce sales to all customers, as well as situations where he discloses and intends to have only high type consumers served. For example at $q = 0$ M will find disclosure and serving all consumers profitably if disclosure costs are low enough, similarly if $q = \overline{q}$ it is optimal for M to disclose and serve high type consumers only. We can thus use the separating equilibrium from the above lemma as the starting point.

Let us for the moment assume, that M already decided on how to divide the interval Q with regards to what consumers he wants to serve, that is, let us assume that M will set a wholesale price of w_ℓ or $w_\ell^D(q)$ if $q \in Q_\ell = [0, \hat{q}_\ell^h]$ and the wholesale price will be w_h or $w_h^D(q)$ if $q \in Q_h = (\hat{q}_\ell^h, \overline{q}]$ for some $\hat{q}_\ell^h \in (0, \overline{q})$. By Q_i^D we will denote the region of the type space Q where M chooses to disclose and sets the corresponding wholesale price $w_i^D(q)$ and similarly, Q_i^{ND} denotes the a region without disclosure and corresponding price $w_i\left(E(Q_i^{ND})\right)$. As before, we will write $E(Q_i^j) = E(q|q \in Q_i^j)$ with $i \in \{\ell, h\}, j \in \{\text{D}, \text{ND}\}$.

Comparing the wholesale pricing schemes in the interval Q_h with and without disclosure, it is clear that for sufficiently small disclosure costs, M has an incentive to disclose his quality for very high quality levels. This is easily seen by comparing the wholesale prices w_h^D and w_h:

$$w_h^D(q) - w_h\left(E(Q_h)\right) = \theta_h(q - E(Q_h))$$

This difference clearly is negative for $q < E(Q_h)$ and (weakly) positive otherwise. The difference is maximized at $q = \overline{q}$, meaning that M has the greatest incentives to disclose his quality when his quality is the highest. Given that consumers know, M would disclose his quality whenever it is the highest, they reason that the quality must be lower if it is not revealed leading to M preferring to disclose his quality for marginally smaller values of q. This unraveling continues until the increase in revenue equals the costs for disclosure, that is, until

$$w_h^D(\hat{q}_h) - w_h\left(E\left(Q_h^{ND}\right)\right) = \theta_h[\hat{q}_h - E(Q_h^{ND})] = d \tag{3}$$

This process of unraveling is precisely the same identified in most of the previous literature on disclosure, and it is clear that with positive disclosure costs M will never disclose for all quality realizations if he intends to serve all consumers. Clearly, for positive disclosure costs d, $\hat{q}_h > \hat{q}_\ell^h$.

The more interesting, and different, situation is the one where M wants to induce R to serve all consumers. We have already seen that with disclosed quality levels, M's wholesale price is decreasing in the quality q, which as we will see, changes the unraveling behavior fundamentally.

To this end, we again compare wholesale prices with and without disclosure:

$$\begin{aligned} w_\ell^D(q) - w_\ell\left(E(Q_\ell)\right) &= m\theta_\ell\left(q - E(Q_\ell)\right) + n_h\theta_h\left(E(Q_h) - q\right) \\ &= -q(n_h\theta_h - m\theta_\ell) - m\theta_\ell E(Q_\ell) + n_h\theta_h E(Q_h) \end{aligned}$$

For fixed values $E(Q_\ell)$ and $E(Q_h)$, the difference is decreasing in q, and since it is positive for $q = 0$, it is positive for any $q \in Q_\ell$, meaning that for very small disclosure costs d, M will choose to disclose the quality for all $q \in Q_\ell$. This also implies that it can not be the case that M chooses to disclose his quality for some $q' \in Q_\ell$ but he chooses not to disclose for some $q < q'$. Which means that it will be never the case that the manufacturer chooses to disclose his quality for all but the smallest quality levels as is commonly the case in the disclosure literature. Instead, M will either disclose the quality for all $q \in Q_\ell$ or for all values in $Q_\ell^D = [0, \hat{q}_\ell]$ where $\hat{q}_\ell$ is defined through

$$w_\ell^D(\hat{q}_\ell) - w_\ell\left(E\left(Q_\ell^{ND}\right)\right) = m\theta_\ell\left(\hat{q}_\ell - E\left(Q_\ell^{ND}\right)\right) + n_h\theta_h\left(E\left(Q_h^{ND}\right) - \hat{q}_\ell\right) = d. \tag{4}$$

Depending on the parameters, this equation may have a solution $\hat{q}_\ell \in Q_\ell$. In this case Q_ℓ consists of Q_ℓ^D and Q_ℓ^{ND}, otherwise $Q_\ell = Q_\ell^D$. The above discussion implies that Q_ℓ will include Q_ℓ^{ND} whenever disclosure costs are at an intermediate level and for smaller disclosure costs, $Q_\ell = Q_\ell^D$.

Combining the disclosure incentives when selling to high type consumers only with the just derived incentives when M intends to sell to all consumers, we observe that if disclosure costs are sufficiently small, M will always disclose for the lowest and the highest quality realizations. What we have not yet calculated are the thresholds quality levels for which M switches from disclosure to non-disclosure and from selling to all consumers to serving only high type consumers. We have seen that Q_h will always consist of Q_h^D and Q_h^{ND}, and with the two possibilities for the interval Q_ℓ two situations might emerge in equilibrium. $\hat{q}_h$ is always defined by equation (3). For the rest of the interval Q, we have to distinguish the two different scenarios for the interval Q_ℓ.

First, M may not disclose q in regions where he intends to sell to all consumers, as well as in regions where sales are only made to high-type consumers, which as we know happens for intermediate disclosure costs, and in this case equation (4) has a solution. In this case, the type space will be partitioned as shown in the following picture:

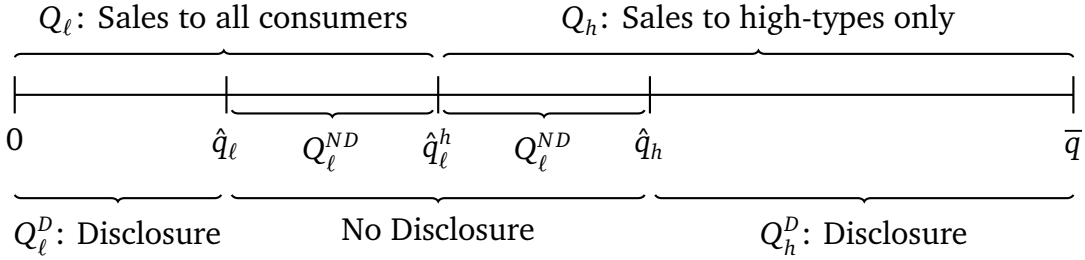

Figure 1: Partitioning of the Type Space for Intermediate Disclosure Costs

As $\hat{q}_\ell$ and $\hat{q}_h$ are defined by equations (3) and (4), the remaining threshold to be calculated is $\hat{q}_\ell^h$. At the threshold $\hat{q}_\ell^h$, M is in different between sales to all consumers and sales to the high-types only, both without disclosing his price. Let $\pi_m(w)$ denote M's profit, ignoring disclosure costs, where for ease of notation $w = w_i^D$ includes disclosure of M, and $w = w_i$ implies no-disclosure, with $i \in \{\ell, h\}$. $\hat{q}_\ell^h$ is then defined by:

$$\pi_M\left[w_h\left(E\left(Q_h^{ND}\right)\right)\right] = \pi_M\left[w_\ell\left(E\left(Q_\ell^{ND}\right)\right)\right] \tag{5}$$

Where the left hand site of this equation is increasing in $\hat{q}_\ell^h$ and the right hand side is decreasing in the value $\hat{q}_\ell^h$.

Alternatively the parameters might make M disclose for any quality when sales are made to all consumers, as outlined in the next figure

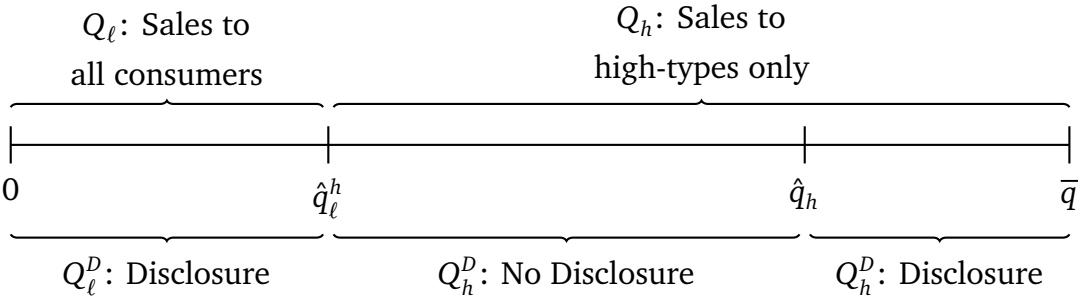

Figure 2: Partitioning of the Type Space for Small Disclosure Costs

In this case, M switches directly from selling to all consumers and disclosing, to serving only the high type consumers, which as we have seen before, must for some interval happen without disclosure given that $d > 0$. In such a situation, we only need to calculate one remaining threshold. The threshold $\hat{q}_h$, characterizing the switch from serving the high type consumers only without and with disclosure, is again defined by (3). The remaining threshold, for a given $\hat{q}_h$ defining the value $\hat{q}_\ell^h$ in this setting, characterizes a situation where the manufacturer is indifferent between serving all consumers while disclosing the quality and serving the high type consumers only, then without disclosure. $\hat{q}_\ell^h$ is implicitly defined by the following equations.

$$\pi_M\left[w_\ell^D(\hat{q}_\ell^h)\right] - \pi_M\left[w_h\left(E\left(Q_h^{ND}\right)\right)\right] = d \tag{6}$$

As $\pi_M\left[w_\ell^D(\hat{q}_\ell^h)\right]$ is decreasing in $\hat{q}$ and $\pi_M\left[w_h\left(E\left(Q_h^{ND}\right)\right)\right]$ is increasing in $\hat{q}_\ell^h$, the assumption on the parameters imply that this equation has a solution for sufficiently small disclosure costs d.

The following proposition summarizes the findings of this section:

Proposition 1. *For sufficiently small disclosure costs, M discloses his products' quality for a all levels below* $\min\{\hat{q}_\ell^h, \hat{q}_\ell\}$ *and above* $\hat{q}_h$ *and he doesn't disclose q for intermediate levels.*
If equation (4) *has a solution, the type space Q is partitioned into* $Q_\ell^D = [0, \hat{q}_\ell], Q_\ell^{ND} = (\hat{q}_\ell, \hat{q}_\ell^h], Q_h^{ND} = (\hat{q}_\ell^h, \hat{q}_h], Q_h^D = [\hat{q}, \overline{q}]$ *where the thresholds are defined trough equations* (3) *to* (5).
Else the type space is partitioned into $Q_\ell^D = [0, \hat{q}_\ell^h], Q_\ell^{ND} = \emptyset, Q_h^{ND} = (\hat{q}_\ell^h, \hat{q}_h], Q_h^D = [\hat{q}, \overline{q}]$ *with thresholds defined by equations* (3) *and* (6).
Wholesale and retail pricing schemes are as follows:

$$w = \begin{cases} w_\ell^D(q) & \text{if} \quad q \in Q_\ell^D \\ w_\ell\left(E\left(Q_\ell^{ND}\right)\right) & \text{if} \quad q \in Q_\ell^{ND} \\ w_h\left(E\left(Q_h^{ND}\right)\right) & \text{if} \quad q \in Q_h^D \\ w_h^D(q) & \text{if} \quad q \in Q_h^{ND} \end{cases} \quad \text{and} \quad p = \begin{cases} p_\ell^D(q) & \text{if} \quad w = w_\ell^D(q) \\ p_\ell\left(E\left(Q_\ell^{ND}\right)\right) & \text{if} \quad w = w_\ell\left(E\left(Q_\ell^{ND}\right)\right) \\ p_h\left(E\left(Q_h^{ND}\right)\right) & \text{if} \quad w = w_h\left(E\left(Q_h^{ND}\right)\right) \\ p_h^D(q) & \text{if} \quad w = w_h^D(q) \end{cases}$$

5 Conclusion

This paper has shown that if a Manufacturer of an experience good in a vertical supply chain setup is given the opportunity to disclose his quality at positive costs, he will choose to do so for any possible realization of the quality except for some intermediate values.

This is in stark contrast to the usual unraveling result, where, in a direct-selling setup, the firm will disclose the quality for all but a range of the smallest possible values. The reasoning is that the firm can extract higher rents from consumers if they perceive the quality to be higher. Given that the firm has the largest incentives to disclose the quality of its product if the quality is at the highest level, consumers expect the quality to be lower than the highest level if the firm does not disclose. This generates disclosure incentives for slightly smaller realizations of the quality, which again reduces consumers expectations if no disclosure is observed. This unraveling process continues for all but the smallest quality realizations where the additional revenue after disclosure is outweighed by the disclosure costs.

In the presented model of a vertical supply chain, this effect and the unraveling from the top are also present. But additionally, the profit of the manufacturing firm is decreasing in the consumers' perceived quality whenever the manufacturer targets as many consumers as possible. This implies that the manufacturer now also has an incentive to disclose the product quality at the lowest level, which makes consumers reason that if many consumers are served and no disclosure is observed the quality must be higher than the lowest level. Keeping the served consumers constant, this reduces the manufacturers profit leading to disclosure incentives for quality realizations slightly above the lowest one, which then leads to consumers increasing their expectations

if they do not observe disclosure, and as the unraveling from the top, this process continues until the additional revenue after disclosure is outweighed by the disclosure costs.

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