Quality differentiation and entry choice between online and offline markets

Yijuan Chen
Australian National University

Xiangting Hu
Renmin University of China

Sanxi Li
Renmin University of China

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Quality differentiation and entry choice between online and offline markets*

Yijuan Chen† Xiangting Hu‡ Sanxi Li§
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Abstract

We study a model where an entrant chooses between online and offline markets to compete with an offline-market incumbent. When consumers buy a product from the online market, they cannot inspect the product’s quality prior to purchase. Conventional wisdom and some literature suggest that this feature drives low-quality products to hide themselves in the online market. However, the literature on vertical product differentiation indicates that a firm may prefer to reveal its product quality in the offline market, because quality differentiation helps alleviate price competition. We show that under fairly general conditions the entrant will choose the offline market for not only the highest qualities but also the lowest ones, and choose the online market for intermediate qualities. While the average quality of the online good is lower than the incumbent’s quality, the actual quality of the online good may be higher than that.

Keywords: online vs. offline competition; market choice by entrant; quality differentiation

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1 Introduction

When consumers buy goods such as toys, clothing, and furniture from an online market, they can hardly inspect a product’s quality prior to purchase. In such cases what is usually regarded as a search good in an offline market is, at least partially, turned into an experience good in the online market. Conventional wisdom and some literature suggest that the online market has a "pooling effect," which attracts firms with low-quality products, because it provides those firms with the opportunity to pool with higher-quality products. For example, Jin and Cato (2007) show that ungraded sport cards sold in the online market are of lower quality than those in the offline market. This is akin to a standard result in the literature of information disclosure

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†Australian National University; E-mail: yijuan.chen@anu.edu.au
‡Renmin University of China; E-mail: xiangthu@ruc.edu.cn
§Renmin University of China; E-mail: lisanxi@gmail.com

1For a review of recent literature on online versus offline competition, see Lieber and Syverson (2011).
(Grossman and Hart 1980, Jovanovic 1982), which shows that firms with higher qualities have a stronger incentive to disclose their qualities, and if disclosure is costly, firms with lower qualities will pool with each other by not disclosing.

However, the literature on vertical product differentiation (Shaked and Sutton 1982) indicates another driving force that may also affect a firm’s choice of marketplace. The literature shows that vertical product differentiation may help alleviate price competition, and thus a firm may voluntarily choose to provide a low-quality product if the competitor produces a high-quality good. In the context of market choice, this means a low-quality firm may want to choose the offline market if the competitor’s quality is high. In other words, one can argue that the offline market has a "differentiation effect" that may also attract low-quality firms.

Since the pooling effect and the differentiation effect are in opposite directions, it is not clear overall how they affect a firm’s market choice. In this paper, we investigate a situation where an entrant chooses between online and offline markets to compete with an offline incumbent. We develop a signalling-game model that draws upon the literature of quality disclosure and that of vertical product differentiation. We show that, due to the differentiation effect, in the offline market the entrant’s profit increases with the difference between her product’s quality and the incumbent’s quality. This drives the entrant with high-differentiated product qualities, which consist of not only the highest qualities but also the lowest ones, to choose the offline market.

On the other hand, the differentiation effect diminishes as the entrant’s product quality becomes closer to the incumbent’s. We assume that the offline market is more costly than the online market. Consequently, there is an interval of qualities such that at the two boundary points the entrant will be indifferent between the two markets. For medium-differentiated qualities, which are slightly above the lower bound or below the upper bound, the entrant will choose the online market mainly to save the cost of the offline market. The pooling effect then drives the low-differentiated qualities, namely those near the incumbent’s quality, to pool with the medium-differentiated qualities in the online market.

The differentiation effect implies that, all else equal, the offline market will be more attractive to the entrant with higher qualities. As a result, the average quality of the online good is lower than the quality of the incumbent’s. However, the upper bound of the aforementioned quality interval is above the incumbent’s quality. Hence the actual quality of the online good may be higher than the incumbent’s.

In this paper we choose a simple model that allows us to illustrate the pooling and differentiation effects in an easy way. The results can also serve as a benchmark for investigating more features of online / offline business in the future. For example, quality of online products can be fully or partially revealed by consumer review mechanisms and / or third-party web sites. Thus in a more dynamic setting one can study if review mechanisms and third-party web sites attenuate or amplify the pooling and differentiation effects, and consequently how they affect a firm’s market choice. Moreover, for tractability of the analysis we have assumed exogenous product qualities, an assumption that remains to be relaxed in future studies.

We discuss the results in more detail in Section 2 after we present the model, and Section 3 2

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2See Dranove and Jin (2010) for a recent review of literature on quality disclosure.
concludes. The Appendix contains proofs of a lemma and a proposition.

2 Model

2.1 Set-up

There are two profit-maximizing firms $i = A, B$. Firm $A$ is an entrant who chooses between an offline market and an online market, and firm $B$ is an incumbent who sells in the offline market. Each firm’s product quality $q_i$ is an independent draw from a uniform distribution on $[q, \bar{q}]$ with $0 < q < \bar{q}$. A firm’s product quality is observable to the public in the offline market. But if firm $A$ sells online, then $q_A$ will be unobservable to consumers prior to consumption and to the incumbent as well.\(^3\) After firm $A$ chooses the market, the firms simultaneously post their prices $p_i$, which are publicly observable.

We assume that the fixed cost of selling on the offline market, including rent and utility expenses, is larger than the fixed cost of selling online. For simplicity, we assume the fixed cost for the offline market is $F$ and the fixed cost for the online market is zero. The marginal cost of production is constant and normalized to 0.

The firms compete for a continuum of utility-maximizing consumers, indexed by $j$. Each consumer has a unitary demand and is characterized by a type $\lambda_j$, which measures the consumer’s marginal utility of quality and is an independent draw from a uniform distribution on $[\underline{\lambda}, \bar{\lambda}]$ with $0 < \underline{\lambda} < \bar{\lambda}$. Consumers are of mass $M = \bar{\lambda} - \underline{\lambda}$. For ease of illustrating the differentiation effect, we adopt a standard specification of consumer utility as in Belleflamme and Peitz (2010): A consumer’s (indirect) utility from buying firm $i$’s product is $u(q_i, p_i, \lambda_j) = r + \lambda_j q_i - p_i$, where $r > 0$ represents the basic willingness to pay for the product, and is assumed to be sufficiently large so that all consumers will buy from one firm in equilibrium.

Denote firm $i$’s profit by $\pi_i$. If a mass of $m$ consumers buys from firm $i$, then $\pi_i = mp_i - F$ if the firm sells in the offline market, and $\pi_i = mp_i$ if it sells online.

2.2 Analysis

A strategy of the entrant (firm $A$) is to choose a market and then a price, and a strategy of the incumbent (firm $B$) is to choose a price given the entrant’s market choice. A consumer’s strategy is to decide on which firm to buy from given the prices and the observability of product quality. Because the entrant’s product quality will be unobservable in the online market prior to purchase, the game is essentially a dynamic game with incomplete information, and we use the perfect Bayesian equilibrium (PBE), which consists of a sequentially rational strategy profile and a consistent belief system, as our solution concept.

A PBE is separating if the entrant always chooses the offline market, as this will lead to perfect revelation of its product quality. An equilibrium is pooling if the entrant always chooses the online market, since the market choice will not reveal extra information about its quality. An\(^3\) We model uncertainty in the online market as consumers’ uncertainty about a firm’s product quality. In contrast, Loginova (2009) assumes that consumers are uncertain about their own types if they buy online. Therefore quality signalling by the firm’s market choice is abstracted from her model.
equilibrium is partially pooling (partially separating) if for some qualities the entrant chooses the offline market while for others it chooses the online market.

In equilibrium the entrant will choose a market if the profit from that market is higher than that from the other. We will first study the firms’ equilibrium behaviors in two situations: (i) the entrant has chosen the offline market, and (ii) the entrant has chosen the online market.

Lemma 1 below shows the profits of the two firms if they compete in the offline market.

**Lemma 1** Suppose both firms sell in the offline market. Then, given \((q_i, q_{-i})\) with \(q_i > q_{-i}\), in equilibrium the firms’ profits are 
\[
\pi_i = \delta_H (q_i - q_{-i}) - F \quad \text{and} \quad \pi_{-i} = \delta_L (q_i - q_{-i}) - F,
\]
where 
\[
\delta_L = \frac{1}{9}(2\lambda - \Delta)^2 \quad \text{and} \quad \delta_H = \frac{1}{9}(2\lambda - \Delta)^2.
\]

**Proof.** In the appendix.

Lemma 1 is a standard result in the literature of vertical product differentiation (Belleflamme and Peitz 2010): In the offline market, if the firms have the same quality, they will essentially be engaged in a cut-throat Bertrand competition. But when their qualities differ, their equilibrium profits both increase with the quality difference \((q_i - q_{-i})\). Hence, quality differentiation helps alleviate price competition and leads to higher profits of both firms, with the higher-quality firm making more profit than the other.

Next, if firm \(A\) chooses the online market, then consumers have to base their purchase decision on the expected quality of the firm’s product. Suppose there is a set \(Q_A \subset [q, q]\) such that firm \(A\) will choose the online market if \(q_A \in Q_A\). Denote \(Q_A = E[q_A | q_A \in Q_A]\), which is the expected quality of firm \(A\)’s product from consumers’ perspective. The next corollary characterizes the firms’ equilibrium profits if the entrant chooses the online market:

**Corollary 1** If firm \(A\) chooses the online market, then in equilibrium \(\pi_A = \delta_H (Q_A - q_B)\) and \(\pi_B = \delta_L (Q_A - q_B) - F\) if \(Q_A > q_B\); \(\pi_A = \delta_L (q_B - Q_A)\) and \(\pi_B = \delta_H (q_B - Q_A) - F\) if \(Q_A < q_B\).

**Proof.** The proof essentially replicates that of Lemma 1 by replacing \(q_i\) and \(q_{-i}\) with \(q_A\) and \(q_B\), and thus is skipped.

The proposition below characterizes a partial pooling equilibrium where the entrant chooses the offline market if its product quality is sufficiently high or sufficiently low, while for intermediate qualities it chooses the online market.

**Proposition 1** Let \(q_A = q_B - \frac{2q_A + \delta_L}{\delta_H + 3\delta_L} \cdot F\) and \(\overline{q}_A = q_B + \frac{2}{\delta_H + 3\delta_L} \cdot F\). If \(q < q_A\) and \(q_A < \overline{q}\), then there exists an equilibrium where firm \(A\) will choose the offline market if \(q_A \in [q, q_A] \cup (\overline{q}_A, \overline{q}]\) and the online market if \(q_A \in [\overline{q}_A, \overline{q}]\).

**Proof.** In the appendix.
The differentiation effect and the pooling effect together give rise to the entrant’s market choice in Proposition 1, the intuition of which has several layers. First, as Lemma 1 shows, the differentiation effect increases with the difference in the firms’ product qualities. Hence the entrant with a quality close to the high-end $q$ or the low-end $q$ has a stronger incentive to choose the offline market than that with a quality near the incumbent’s. For the highest qualities $[q_A, q]$ as well as the lowest ones $[q, q_A]$, the entrant has no incentive to pool with the qualities in the online market because if going online, it will be regarded as having an intermediate quality, which, due to competition with the incumbent, will lead to a less profitable price than in the offline market. Consequently, as shown in Figure 1, the entrant will choose the offline market despite its higher fixed cost.

Secondly, the differentiation effect diminishes as the entrant’s quality gets closer to the incumbent’s. For the entrant’s quality that is slightly above $q_A$ or below $q_A$, were the two markets equally costly the entrant would still have made a higher profit from the offline market than going online. However, the higher fixed cost $F$ of the offline market now drives the entrant to choose the online market. Those medium-differentiated qualities then become the target for qualities around $q_B$ to pool with in the online market. It is worth noting that, in contrast to conventional wisdom, in this case the higher qualities (those close to $q_B$) want to pool with the lower qualities (those close to $q_A$), not the other way around. Moreover, $q_A > q_B$ implies that the actual quality of the online product may be higher than the incumbent’s.

Thirdly, Proposition 1 implies that in equilibrium the expected quality of the online product is $Q_A = q_B - \frac{\delta_H - \delta_L}{\delta_L (\delta_H + \delta_L)} \cdot F < q_B$, as shown in Figure 1. That is, on average the online product has a lower quality than the offline product. To see the intuition of this result, note that because $\delta_H > \delta_L$, for $q_A'$ and $q_A''$ such that $q_B - q_A' = q_A'' - q_B$, (i.e. $q_A'$ and $q_A''$ equally distant from $q_B$), the higher quality $q_A''$’s profit from choosing the offline market is higher than that of the lower quality $q_A'$. So the offline market is more attractive to $q_A''$ than to $q_A'$. Hence, there are more $q_A < q_B$ to choose the online market than $q_A > q_B$. Consequently, the expected quality of the online product falls below the incumbent’s product in the offline market.

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This is contrasted with the result in Board (2009), where two competing firms simultaneously choose to disclose product qualities. He is focused on an equilibrium where the higher-quality firm always discloses. This corresponds to a hypothesis in our paper that the incumbent’s product quality is always higher than the online product, which, as Proposition 1 shows, may not be true.
It is worth noting that in Proposition 1 $q_A$ and $\overline{q}_A$ are independent of $q$ and $\overline{q}$. Hence, the condition that $q < q_A$ and $\overline{q}_A < \overline{q}$, under which the partial-pooling equilibrium exists, is fairly general. Below is a numerical example where $[q_A, \overline{q}_A]$ is characterized given $q_B$, $\lambda$, $\overline{\lambda}$, and $F$.

**Numerical Example:** Suppose $q_B = 10$, $\lambda = 1$, $\overline{\lambda} = 20$, and $F = 5$. Then Proposition 1 implies that $q_A = 9.77$, $\overline{q}_A = 10.05$, and thus $Q_A = 9.91$. When the entrant chooses the online market, i.e., $q_A \in [q_A, \overline{q}_A]$, the profits of the entrant and the incumbent are $\pi_A = 3.24$ and $\pi_B = 10.23$.

### 3 Conclusion

To summarize, by taking into account the effect of vertical product differentiation on a firm’s market choice, we show that an entrant with the lowest qualities may prefer the offline market. In the online market, higher qualities may have the incentive to pool with lower qualities. Moreover, the actual quality of the online product may be higher than the offline incumbent’s. On the other hand, consistent with prior studies, we show that the average quality of the online product is lower than the offline incumbent’s. These findings can be a starting point for more comprehensive studies in the future. For example, one may endogenize the entrant’s quality choice prior to its market choice. It will also be interesting to see how other features of the online market, such as market size and consumer review systems, affect a firm’s market choice. Moreover, one may explore the possibility that the incumbent also has the incentive to enter the online market.

### 4 Appendix

#### 4.1 Proof of Lemma 1

**Proof.** The proof is similar to that in Belleflamme and Peitz (2010) for a standard model of vertical product differentiation in an offline market: When both firms choose to sell in the offline market, $(q_B, p_B)$ and $(q_A, p_A)$ are common knowledge. Without loss of generality, given $(q_B, p_B)$ and $(q_A, p_A)$ with $q_B < q_A$ and $p_B < p_A$, there will be a consumer with $\hat{\lambda}$ who will be indifferent between the two firms:

$$
\hat{\lambda} q_B - p_B = \hat{\lambda} q_A - p_A.
$$

$$
\Rightarrow \hat{\lambda} = \frac{p_B - p_A}{q_A - q_B}.
$$

Hence, firm B’s profit is $\pi_B = (\hat{\lambda} - \lambda) p_B - F = \left(\frac{p_A - p_B}{q_A - q_B} - \lambda\right) p_B - F$, while firm A’s profit is $\pi_A = (\hat{\lambda} - \lambda) p_B - F = \left(\lambda - \frac{p_A - p_B}{q_A - q_B}\right) p_A - F$.

Given $q_B$ and $q_A$, each firm chooses the price to maximize its profit. The first-order condition for firm B implies $\frac{p_A - p_B}{q_A - q_B} - \lambda - \frac{p_B}{q_A - q_B} = 0$, which leads to

$$
p_B = \frac{1}{2} \left[p_A - \lambda(q_A - q_B)\right].
$$
The first-order condition for firm A implies \( \frac{p_A}{q_A - q_B} - \frac{p_A}{q_A - q_B} = 0 \), which implies
\[
p_A = \frac{1}{2} \left[ \frac{1}{\lambda} (q_A - q_B) + p_B \right].
\]
Solving the two first-order conditions for \( p_B \) and \( p_A \), we have
\[
p_B = \frac{1}{3} (\lambda - 2\lambda) (q_A - q_B),
\]
\[
p_A = \frac{1}{3} (2\lambda - \lambda) (q_A - q_B).
\]
Thus given \( q_B < q_A \), in equilibrium
\[
\pi_B(q_B, q_A) = \frac{(p_A - p_B)}{q_A - q_B} p_B - F
\]
\[
= \frac{1}{3} (2\lambda - \lambda) (q_A - q_B) - \frac{1}{3} (\lambda - 2\lambda) (q_A - q_B) - \lambda \frac{1}{3} (\lambda - 2\lambda) (q_A - q_B) - F
\]
\[
= \frac{1}{9} (\lambda - 2\lambda)^2 (q_A - q_B) - F
\]
\[
\pi_A(q_B, q_A) = (\lambda - \frac{p_A - p_B}{q_A - q_B}) p_A - F
\]
\[
= (\lambda - \frac{1}{3} (2\lambda - \lambda) (q_A - q_B) - \frac{1}{3} (\lambda - 2\lambda) (q_A - q_B)) \frac{1}{3} (2\lambda - \lambda) (q_A - q_B) - F
\]
\[
= \frac{1}{9} (2\lambda - \lambda)^2 (q_A - q_B) - F.
\]

4.2 Proof of Proposition 1

**Proof.** First suppose \( Q_A < q_B \). We consider two possible cases.

**Case 1:** \( q_A \in [q, q_B] \).

If firm A chooses the offline market, then by Lemma 1 \( \pi_A = \delta_L(q_B - q_A) - F \). If firm A chooses the online market, then by Corollary 1 \( \pi_A = \delta_L(q_B - Q_A) \). Firm A will choose the online market if \( \delta_L(q_B - Q_A) \geq \delta_L(q_B - q_A) - F \), that is,
\[
q_A \geq Q_A - \frac{F}{\delta_L}.
\]

**Case 2:** \( q_A \in (q_B, q] \).

If firm A chooses the offline market, then \( \pi_A = \delta_H(q_A - q_B) - F \). If firm A chooses the online market, then \( \pi_A = \delta_L(q_B - Q_A) \). Firm A will choose the online market when \( \delta_L(q_B - Q_A) \geq \delta_H(q_A - q_B) - F \), that is,
\[
q_A \leq q_B + \frac{1}{\delta_H} [F + \delta_L(q_B - Q_A)].
\]

[1] and [2] imply that \( Q_A = \frac{1}{2} \left[ \left( Q_A - \frac{F}{\delta_L} \right) + \left( \frac{1}{\delta_H} [F + \delta_L(q_B - Q_A)] \right) \right] \). Solving this equation
Note that $Q_A < q_B$ confirms our assumption.

Since firm $A$ will choose to sell online when $q_A \in [Q_A - \frac{F}{\delta_L}, q_B + \frac{1}{\delta_H}[F + \delta_L(q_B - Q_A)]]$, plugging (3) into the lower bound and the upper bound of the set, we get

$$q_A = q_B - \frac{2}{\delta_H + \delta_L} \cdot \frac{\delta_H - \delta_L}{\delta_L} \cdot F,$$

$$\bar{q}_A = q_B + \frac{2}{\delta_H + \delta_L} \cdot F.$$

To complete the description of the PBE, we need to construct the consumers’ belief system. On the equilibrium path, the belief system is straightforward: By assumption, if the entrant chooses the online market, consumers can verify her quality. On the other hand, if the entrant chooses the online market, consumers believe that her quality is $Q_A$. Then the characterization of $q_A$ and $\bar{q}_A$ implies that an offline entrant has no incentive to deviate to the online market, and vice versa.

A subtle issue remains in the off-equilibrium-path belief: Since the entrant chooses a marketplace and then sets the price, a quality in the online market may want to post a different price in order to separate itself from other online qualities. In particular, $q_A$ or $\bar{q}_A$ has the strongest incentive to deviate in this way, because the deviation will allow them to reveal their types while not paying the offline-market cost $F$. To deter this kind of deviation, it suffices to let consumers hold the off-equilibrium-path belief that any online price other than the one in equilibrium comes from an entrant with quality $Q_A$, because then the most profitable price-deviation in the online market will lead to the same profit as staying on the equilibrium path.

Next, we will show that it cannot be $Q_A > q_B$ in equilibrium: Suppose, toward a contradiction, $Q_A > q_B$. There are two cases:

**Case 1:** $q_A \in [q, q_B]$.

If firm $A$ chooses the offline market, then $\pi_A = \delta_L(q_B - q_A) - F$. If firm $A$ chooses the online market, then $\pi_A = \delta_H(Q_A - q_B)$. Firm $A$ will choose the online market if $\delta_H(Q_A - q_B) \geq \delta_L(q_B - q_A) - F$, that is, $q_A \geq q_B - \frac{1}{\delta_L}[F + \delta_H(Q_A - q_B)]$.

**Case 2:** $q_A \in (q_B, \bar{q})$.

If firm $A$ chooses the offline market, then $\pi_A = \delta_H(q_A - q_B) - F$. If firm $A$ chooses the online market, then $\pi_A = \delta_H(Q_A - q_B)$. Firm $A$ will choose the online market if $\delta_H(Q_A - q_B) \geq \delta_L(q_A - q_B) - F$, that is, $q_A \leq Q_A + \frac{F}{\delta_H}$.

Hence, $Q_A = \frac{1}{2} \left( Q_A + \frac{F}{\delta_H} \right) + \left( q_B - \frac{1}{\delta_L}[F + \delta_H(Q_A - q_B)] \right)$. Solving the equation for $Q_A$, we have $Q_A = q_B - \frac{\delta_H - \delta_L}{\delta_H \delta_L} \cdot F < q_B$, contradicting $Q_A > q_B$. Therefore it cannot be $Q_A > q_B$ in equilibrium. ■

**References**


