Material for referees

We would like to express our gratitude to the Area Editor and the three referees for their careful and constructive suggestions. We believe that the incorporation of all of their suggestions has greatly improved the paper. The revisions are as follows.

Revisions made in response to suggestions by the Area Editor

AE-1 We could obtain our result also in a Bertrand setting. We added a new section (Section 3 in the current version) to show the results. In addition, we thank the Area Editor for suggesting that we familiarize ourselves with the work of Coughlan and Soberman (2005), which was an important source for us.

AE-2 Following Reviewer 1's comment, we removed the improper assumptions on both a and b in a Cournot model. Furthermore, we explicitly derive the set of parameters that are needed for our results (in Section 2). As for the general conditions on the demand functions for our result, we present our conjecture that our result holds for demand functions that are sufficiently elastic in the low-price region (in the last section). Unfortunately, we were not able to prove it mathematically.

AE-3 As for a Cournot model, we provide a detailed explanation on what drives the result after Proposition 1. In particular, we explain in detail why the strategic interaction between two high-end firms is necessary for our result.

AE-4 Following Reviewer 1's suggestion, in the Appendix, we show that our result holds even if there is only one firm in the low-end market. Given this result, in the last paragraph of Section 2, we explicitly report that $p^l = 0$ is not an essential assumption for our result and our analysis applies to the case in which entries in the low-end market are constrained due to the existence of entry costs.

AE-5 Following Reviewer 3's advice, at the end of Section 3, we compare our paper with Chen and Riordan (2007) and explain the differences between the two papers. The reason that we placed the discussion in Section 3 is that Chen and Riordan (2007) use a price competition model that is suitable for comparison with our price competition model. We thank Reviewer 3 for informing us of this important paper.

AE-6 Following Reviewer 3's advice, we modified misleading expressions that stress the high-end firms' price increases in response to low-end firms' entries. We also thank Reviewer 3 for referring us to Stiglitz (1987), an important source for us. It is referenced in footnote 8.

AE-7 Following Reviewer 3's advice, we deleted the misleading words "status goods" and modified the expressions in the sentence.

Revisions made in response to suggestions by Reviewer 1

(The numbers below correspond to those of "Major concerns" and "Other comments" in Reviewer 1's report.)

1 Please see AE-2.

2 Please see AE-4.

3 Please see AE-1.

4 As stated in AE-2, we removed the improper constraints on parameters following Reviewer 1's comment 4-(i). As for 4-(ii), in the last section, we state our conjecture on other functional forms that seem to produce the same result.

5 Please see AE-3.

6 Please see AE-4.

7 In footnotes 11 and 12, Section 2, we explicitly mention a typical consumer in H and L in our model. We also explain how our demand function can be derived by assuming the distributions on the consumers' willingness to pay.

With regard to Reviewer 1's comment to Q.7, "Are revisions necessary? If so, what revisions need to be made?": As stated above, we think that all items other than (4) are incorporated into the current version. As for (4), we searched for more suitable empirical studies, but, unfortunately, we did not find any. As stated in footnote 7, Section 1, we believe that the fundamental difficulty of such empirical research lies in how to measure the exact changes of incumbent firms' profits caused by entries. We hope that Reviewer 1 allows our insufficient response concerning (4).

Revisions made in response to suggestions by Reviewer 3

(The numbers below correspond to those of "Comments on "The Existence of low-end firms may help high-end firms"" in Reviewer 3's report.)

1 Please see AE-1.

2 Please see the third and fourth sentences of AE-2.

3 In the Appendix, we show that each firm's profit decreases in a number of h firms (with no low-end firms). In the proof for this result, we needed additional proofs (the proofs of Lemmas 5 and 6), which are tedious and straightforward calculations. Because it seemed appropriate to include the proofs of Lemmas 5 and 6 in the supplementary material, we created another file for this material. If the Area Editor and/or Reviewer 3 thinks that the proofs should be in the paper, we would be willing to follow the suggestion.

4 Please see AE-5.

5 In the current version, we show that our result holds even when there is only one firm in the low-end market. In other words, we improve the misleading impression that our result holds only when the degree of competition in the low-end market is higher than that in the high-end market. We think that, due to this improvement, the example of PC in the current version becomes proper.

6 Please see AE-6.

7 Please see AE-7.

Technical appendix

Proof of Lemmas 5 and 6

Before we prove the lemmas, we describe the setting of the model with $n(\geq 2)$ high-end firms. We consider a case in which no firm produces l and the n major firms can potentially sell to both groups of consumers.

We describe how the price p^h is determined given the two groups of consumers. As long as $1 - \sum_{i=1}^{n} q_i \geq a$, no consumer in L buys h. Therefore, p^h is given by

$$p_h = 1 - \sum_{i=1}^{n} q_i.$$

If $1 - \sum_{i=1}^{n} q_i < a$, some consumers in L buy h. Because h and l are completely indifferent to consumers in L, this means that

$$p^h = p^l = \frac{a(1 + b - \sum_{i=1}^{n} q_i)}{a + b}.$$

In summary, p^h is determined as follows.

$$p^h(q) = \begin{cases} 1 - \displaystyle\sum_{i=1}^{n} q_i & \text{if } \displaystyle\sum_{i=1}^{n} q_i \leq 1 - a, \\ \dfrac{a(1 + b - \sum_{i=1}^{n} q_i)}{a + b} & \text{otherwise.} \end{cases}$$

Let $\pi_i(q)$ be the profit function of firm i. For $i = 1, 2, \ldots, n$, this can be expressed as follows.

$$\pi_i(q) = \begin{cases} \left(1 - \displaystyle\sum_{i=1}^{n} q_i\right) q_i & \text{if } \displaystyle\sum_{i=1}^{n} q_i \leq 1 - a, \\ \dfrac{a(1 + b - \sum_{i=1}^{n} q_i) q_i}{a + b} & \text{otherwise.} \end{cases} \tag{1}$$

We solve the local optimal solutions in the two cases: (A) $\sum_{i=1}^{n} q_i$ is small, and (B) it is large. The first-order conditions lead to

$$(A) \quad q_i^A(n) = \frac{1}{n+1}, \quad \sum_{i=1}^{n} q_i^A(n) = \frac{n}{n+1}, \quad \pi^A(n) = \frac{1}{(n+1)^2},$$
$$\text{if } a \leq \frac{1}{n+1}, \tag{2}$$

$$(B)\ \ q_i^B(n)=\frac{1+b}{n+1},\ \ \sum_{i=1}^{n} q_i^B(n)=\frac{n(1+b)}{n+1},\ \ \pi^B(n)=\frac{a(1+b)^2}{(a+b)(n+1)^2},$$
$$\text{if } a\geq \max\left\{\frac{1-nb}{n+1},0\right\}. \quad (3)$$

After some calculus, we have the following lemmas:

Lemma 5 *$q^B(n)$ becomes a Cournot equilibrium if $a \geq (2-(n-1)b)^2/(n+1)(4-(n-3)b)$ or $b \geq 2/(n-1)$. Each firm obtains $\pi^B(n) \equiv a(1+b)^2/(a+b)(n+1)^2$.*

Lemma 6 *$q^A(n)$ becomes a Cournot equilibrium if $a \leq 4/(n+1)(4+(n+1)b)$ is satisfied. Each firm obtains $\pi^A(n) \equiv 1/(n+1)^2$.*

Proof of Lemma 5 We have to check whether the local optimal solution in (3) is also globally optimal.

In case (B), given the quantities supplied by the other firms, if a firm sets a smaller quantity $q_d^B(n)$, which satisfies $\sum_{i=1}^{n-1} q_i^B(n) + q_d^B(n) \leq 1-a$, the profit function is given by

$$\pi_d^B(n)=\left(1-\frac{(n-1)(1+b)}{n+1}-q_d^B(n)\right)q_d^B(n). \quad (4)$$

When $b \geq 2/(n-1)$, this is non-positive for any $q_d^B(n) \geq 0$, and then the interior solution in (3) is better for the deviating firm. When $b < 2/(n-1)$, the first-order condition leads to

$$q_d^B(n)=\frac{2-(n-1)b}{2(n+1)},\ \ \sum_{i=1}^{n-1} q_i^B(n)+q_d^B(n)=\frac{2n+(n-1)b}{2(n+1)},$$
$$\pi_d^B(n)=\frac{(2-(n-1)b)^2}{4(n+1)^2},\ \ \text{if}\ \ a<\frac{2-(n-1)b}{2(n+1)}. \quad (5)$$

If $\pi_d^B(n)$ in (5) is smaller than or equal to π^B in (3), the case (ii) is an equilibrium outcome. The condition under which the solution in (3) is an equilibrium outcome is

$$\frac{(2-(n-1)b)^2}{4(n+1)^2}\leq \frac{a(1+b)^2}{(a+b)(n+1)^2}\ \ \textit{or}\ \ b\geq \frac{2}{n-1}.$$

The condition can be summarized as follows:

$$a \geq a^B(n) \equiv \begin{cases} \dfrac{(2-(n-1)b)^2}{(n+1)(4-(n-3)b)} & \text{if } b<\dfrac{2}{n-1} \\ 0 & \text{if } b \geq \dfrac{2}{n-1}. \end{cases} \quad (6)$$

Therefore, Lemma 5 holds. Q.E.D.

Proof of Lemma 6 We have to check whether the local optimal solution in (2) is also globally optimal.

In case (A), given the quantities supplied by the other firms, if a deviating firm sets a larger quantity, $q_d^A(n)$, which satisfies $\sum_{i=1}^{n-1} q_i^A(n) + q_d^A(n) \geq 1 - a$, the profit function is given by (see (1) and (2))

$$\pi_d^A(n) = \frac{a(1 + b - (n-1)/(n+1) - q_d^A(n))q_d^A(n)}{a+b}. \tag{7}$$

The first-order condition leads to

$$\begin{aligned} q_d^A(n) &= \frac{2+(n+1)b}{2(n+1)}, \quad \sum_{i=1}^{n-1} q_i^A(n) + q_d^A(n) = \frac{2n+(n+1)b}{2(n+1)}, \\ \pi_d^A(n) &= \frac{a(2+(n+1)b)^2}{4(a+b)(n+1)^2}, \quad \text{if} \quad a > a_d^A(n) \equiv \max\left\{\frac{2-(n+1)b}{2(n+1)}, 0\right\}; \end{aligned} \tag{8}$$

otherwise, $q_d^A(n)$ is the corner solution, $q_d^A(n) = 1 - a - \sum_{i=1}^{n-1} q_i^A(n)$, and the interior solution in (2) is better for the deviating firm. That is, if $a < a_d^A(n)$, the interior solution in (2) is an equilibrium outcome. Moreover, if $\pi_d^A(n)$ in (8) is smaller than or equal to $\pi^A(n)$ in (2), the quantities in case (A) are optimal. The condition under which the solution in (2) is an equilibrium outcome is

$$\frac{a(2+(n+1)b)^2}{4(a+b)(n+1)^2} \leq \frac{1}{(n+1)^2} \quad or \quad a \leq \max\left\{\frac{2-(n+1)b}{2(n+1)}, 0\right\}.$$

The latter condition is redundant. The condition under which case (A) is an equilibrium outcome is

$$a \leq a^A(n) \equiv \frac{4}{(n+1)(4+(n+1)b)}. \tag{9}$$

Therefore, Lemma 6 holds. Q.E.D.

We summarize the equilibrium profit:

$$\pi_i = \begin{cases} \dfrac{1}{(n+1)^2} & \text{if } a \leq a^A(n), \\ \dfrac{a(1+b)^2}{(a+b)(n+1)^2} & \text{if } a \geq a^B(n). \end{cases} \tag{10}$$

Because $a^B(n) < a^A(n)$, there are multiple equilibria if $a \in [a^B(n), a^A(n)]$. We can easily find that π_i in (10) is monotonically decreasing in n.