Signaling Quality Through Visibility

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Abstract

We ask whether positions in a search list can signal quality of an experience good if vertically differentiated firms can pay for it. We show that this is possible if only if the correct ranking maximizes the aggregate profit. If uninformed consumers believe the ranking, the ‘correct’ ranking induces homogeneous beliefs among informed and uninformed consumers. In doing so, it facilitates market segmentation. Meanwhile, the ‘wrong’ ranking induces heterogeneous beliefs among consumers and, therefore, softens competition. The market segmentation effect dominates when vertical differentiation is high, while the competition softening effect dominates when it is low. Therefore, positions can reveal quality in the first, but not in the second case.

JEL-Code:  D83, L15, L81

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1 Introduction

Most intermediaries and retailers carry products from competing upstream firms. In many instances, the downstream firm offers those upstream firms the possibility to increase the visibility of their products in exchange for some payment. Conventional retail stores, for example, sometimes charge a placement fee for premium shelf spots (see e.g. Rivlin, 2016). Similarly, on e-commerce sites, payments made by an upstream firm are often an important determinant for its position in the list of products that is shown to consumers. Consider so-called ‘online travel agencies’. On Booking.com, hotels can pay for a ‘Visibility Booster’ to get listed at a ‘better’ position. On Expedia.com, after entering the details of your planned trip you are presented with a list that is not solely sorted with respect to usual criterias, such as ratings and prices.\footnote{Digging through the terms of use, one finds the following quote about the sort order of their ‘Lodging’ category: “[...] The compensation which a property pays us for bookings made through our sites is also a factor for the relative ranking of properties with similar offers, [...]”\footnote{See \url{https://www.expedia.com/p/info-other/legal.htm}, last accessed on 2019/01/08.}}

As firms are willing to pay for certain positions on e-commerce sites and particular shelf spots in brick and mortar stores, those seem to be ‘better’ in some regard, i.e. they appear to have a positive effect on demand. A classical explanation for such a positive demand effect is based on search costs (Athey & Ellison, 2011). If prospective consumers follow some search strategy (e.g. examine the list from the top to the bottom), firms who meet consumers’ needs best are willing to pay most for good positions. This line of argument is plausible for search goods. Yet, it is not fully convincing for experience goods because it relies on the ability of consumers to become fully informed about an offer by paying the search costs and inspecting the product. In the ‘online travel agencies’ example given above, products are better characterized as experience goods than as search goods. The aim of this paper is to explain why firms pay for the increased visibility of their products in situations where search costs are not an issue. More precisely, we examine if and under what conditions ranks or positions in a list can serve as a signal for the quality of an experience good in the spirit of Nelson (1974).

Our setting consists of a vertically differentiated upstream duopoly and a monopolistic intermediary downstream. Both upstream firms sell their good through the intermediary to final consumers. The intermediary’s role is very limited. He only displays the goods in a list to consumers. He can decide which good to put on which position, and he can charge a fee depending on the position the product is displayed on. However, prices are set by the upstream firms. Consumers dif-
fer in their valuation for quality, but not all of them can observe it. Uninformed consumers form beliefs about the quality based on the firms’ positions in the list. Finally, consumers buy the good that yields them the highest expected net utility.

We derive two key results. First, we show that a separating equilibrium, where each firm gets assigned to a specific position with probability one, exists if and only if for given beliefs this assignment maximizes the aggregate profit. Otherwise, the low quality firm always has a larger willingness to pay for the high quality firm’s position and vice versa. On the other hand, if the ‘correct’ ranking maximizes industry profit, the intermediary does not have an incentive to charge fees such that both firms choose the same position.³

Second, we show that the ranking can fully reveal the firms’ qualities if differentiation between them is sufficiently high. It cannot, if differentiation is low. Two opposing effects are at play. The first is a market segmentation effect. All consumers share the same belief if the ‘correct’ ranking is displayed. Consequently, any consumer with a high valuation for quality will buy the high quality good for a high price. If, however, consumers trust the ranking and the ‘wrong’ ranking was displayed, uninformed and informed consumers would no longer share the same belief. In that case not all consumers with a high valuation for quality would buy the same (more expensive) good. Thus, the ‘wrong’ ranking would hinder market segmentation, which lowers the aggregate profit. The second is a competition softening effect. Heterogeneous beliefs would cause the low price firm to set a higher price. The reason is that consumers believing it was the high quality firm would never buy from the more expensive competitor, regardless of how large (or small) the price gap between the firms was. Heterogeneous beliefs, resulting from the ‘wrong’ ranking, would therefore soften competition by reducing incentives to lower prices. This would increase the aggregate profit. We show that the market segmentation effect dominates when differentiation between firms is high, while the competition softening effect dominates in case it is low.

Our model contributes to several strands of literature. Most closely related are papers studying dissipative advertising (for an overview see Bagwell, 2007). The main issues in these papers are whether advertising is necessary to signal quality, and whether it makes signaling less costly (in case it is not necessary) than signaling via prices. Fluet & Garella (2002) and Hertzendorf & Overgaard (2001) examine the case of a vertically differentiated duopoly. They show that advertisement is necessary to signal quality when vertical differentiation between firms is low. Yehezkel

³The crucial assumption for this to hold is that the intermediary charges a lump sum fee, and that firms pay for their realized position and not for the position they have asked for. We show in an extension that if firms pay for their asked position, conditions for a separating equilibrium to exist are harder.
(2008) shows that signaling through advertisement is relatively cheap if the share of informed consumers is low, while price signaling becomes cheaper if the share gets large.

Paying for visibility differs from these approaches in two ways. First, visibility is rivalrous. If one firm is at a better position, the competitor must be at a worse one. This fundamentally changes incentives. In the non-rivalrous case, advertising works whenever the low quality firm does not have an incentive to advertise, given that the high quality firm advertises. In contrast, the low quality firm in our setting can make the high firm less visible by also paying for visibility. Signaling therefore only works if the high quality firm is willing to pay more for visibility than the low quality firm. A second difference, which turns out to be minor, is the presence of a profit maximizing intermediary who is selling visibility. This is analogous to introducing incentives from a billboard seller in the dissipative advertising literature.

Some papers on position auctions have examined the signaling role of positions in search lists (Athey & Ellison, 2011; Chen & He, 2011; Jerath et al., 2011). These signals are also rivalrous. Therefore, which firm has a larger willingness to pay for a signal matters. Yet, the logic of these models only applies to search goods. Search is costly for consumers, therefore, they will start inspecting those sellers they believe meet their needs best. Because consumers always find out quality prior to purchase, the willingness to pay for positions that are examined first differs between firms. Contrary to this, in our model both firms may have a different willingness to pay for positions because some consumers can observe quality. Hence, prices and associated profits will never depend merely on the list position.

The effect of information on competition has been studied in some recent information disclosure papers. Bouton & Kirchsteiger (2015) argue that an informative ranking can harm consumers by reducing competition between vertically differentiated firms. Similarly, Canidio & Gall (2018) show that public information about vertically differentiated firms can soften competition. They derive conditions for firms to disclose too much information from a social perspective. In both papers, consumers share a common belief. Thus, reduced competition does not follow from belief heterogeneity among consumers, but from a more accurate belief about which firm is the high quality firm. The effect of belief heterogeneity on competition in turn has been studied by Hefti et al. (2018) in case of a horizontally differentiated duopoly. These authors show that confusion among consumers can soften competition, because this might reduce the number of indifferent consumers. This is analogous to what happens with heterogeneous beliefs in our model. Consumers believing the low price firm is of high quality are never indifferent between buying from one or the other firm, regardless of their valuation for quality. Firms do therefore not compete for these consumers.
Finally, some authors have argued that the willingness to pay slotting fees for premium shelf spots can serve as a signal for quality (see e.g. Chu, 1992; Lariviere & Padmanabhan, 1997). Slotting allowances are similar to lump sum fees in our model. However, in these models, the payment allows the upstream firm to signal its quality to the downstream firm, while in our case it signals quality to final consumers. Garella & Peitz (2000) show that paying a fee for selling through an intermediary can serve as a signal for quality. The result crucially relies on the possibility of the high quality firm to (costly) disclose its quality, and selling through an intermediary is not rivalrous. Hence, their model is very different to the model presented in this paper.

We proceed as follows. Section 2 presents the model. In Section 3 we derive a sufficient and necessary reduced form condition under which the position can signal quality. Section 4 shows when this condition holds in our model of a vertically differentiated duopoly. Section 5 studies the case where firms do not have to pay for the received position, but for the position they have asked for. Section 6 concludes.

2 Model

Consider a high quality firm $H$ and a low quality competitor $L$ (both she, and indexed by $i$). Both observe their own and the competitor’s type, and produce with zero marginal cost. These firms can sell their product through an intermediary $I$ (he), for example a sales platform, to final consumers. The only role of the intermediary is to display the products in a list to consumers prior to purchase. Hence, he has to put one firm on the high position $r = h$, and the other one on the low position $r = \ell$. He can charge lump sum fees $F^r$ for each attached position. The intermediary knows the type distribution of firms, but does not observe which firm is $H$ and which is $L$.\footnote{With lump sum fees, the intermediary’s optimal strategy does not depend on the true type. The assumption is therefore unimportant with lump sum fees, but would be important in case of proportional fees.}

Each firm $i$ can ask to be at the low position $\tilde{r}_i = \ell$, or to be at the high position $\tilde{r}_i = h$. Instead of modeling an outside option, we assume that they also have the possibility to choose $\tilde{r}_i = 0$, and no fee can be charged when this option is chosen. Hence, a firm always has the possibility to sell the good through the intermediary without paying a fee.\footnote{This assumption can also be interpreted as describing a situation where every firm can join the intermediary for the same fee and firms can additionally invest in increased visibility.} The intermediary then assigns to each firm a position $r_i \in \{\ell, h\}$. We denote this assignment as $r(\tilde{r}_i, \tilde{r}_j) = (r_i, r_j)$. Because the intermediary does not observe types, we assume that if both choose the same...
position $\tilde{r}_i = \tilde{r}_j$, positions are assigned randomly with equal probability. Further, with lump sum fees the intermediary does not care about which firm pays for which position. Hence, it is without loss of generality to assume that he can commit to an assignment rule. We specify this rule as follows. If both firms ask for different positions that are not $\tilde{r}_i = 0$, both are assigned to the position they asked for. This is without loss of generality because the choices $\tilde{r}_i = \ell$ and $\tilde{r}_i = h$ are just labels. This is not the case for the choice $\tilde{r}_i = 0$ because this requires that firm $i$ does not pay any fee, regardless of the assigned position. Specifying a particular assignment for this case would therefore not be without loss of generality. Thus, we denote by $n$ the probability with which a firm asking for position $\ell$ gets assigned to position $\ell$ if the competing firm chooses $\tilde{r}_i = 0$. Equivalently, $m$ is the probability that a firm choosing position $h$ gets assigned to position $h$ if the competing firm chooses $\tilde{r}_i = 0$.

Finally, each firm has to pay for the realized position if its choice was not $\tilde{r}_i = 0$. This assumption is not without loss of generality. It ensures that both firms choose their preferred position instead of strategically choosing the cheaper one, if the competing firm does so as well. Furthermore, it states that each fee is paid at most by one firm. It therefore makes a separating equilibrium easier to exist, compared to the rule where both firms pay for the position they asked for. We examine the alternative case as an extension.

Firms observe the realized positions and simultaneously set their prices $p_i$ to maximize their profits $\Pi_i$, which depend on both, the own and the opponent’s price as well as (perceived) qualities.

Demand is modeled as in Bagwell & Riordan (1991). There is a total mass one of consumers each of whom buys at most one good. Consumers are homogeneous in their valuation for the low quality good, but value the high quality one differently. All consumers’ valuation for the low quality good is given by $V$, while the valuation for the high quality good of a consumer is equal to his type, which is a draw from a uniform distribution between $V$ and $V + 1$. Because the quality difference is normalized to one, $V$ is a measure of vertical product differentiation: differentiation becomes larger as $V$ gets smaller and vice versa. A share $\alpha \geq 0$ of consumers observe the quality of the firms, while the remaining consumers only know the quality distribution. We assume that a consumer’s information and her type are not correlated. All consumers observe both prices and attached positions. We denote the uninformed consumers’ beliefs that $i = H$ when observing prices and positions as $b((p_i, r_i), (p_j, r_j))$.

To sum up, the timing is as follows.

i) $I$ sets lump sum fees ($F^{\ell}, F^h, F^0 = 0$).

ii) Firms observe fees, and simultaneously make their choice $\tilde{r}_i \in \{0, \ell, h\}$.
iii) I observes \((\tilde{r}_i, \tilde{r}_j)\) and assigns positions \((r_i, r_j)\), which are observed by all players, as follows:

- If \(\tilde{r}_i \neq \tilde{r}_j\) and \(\tilde{r}_i, \tilde{r}_j \neq 0\):
  \[r(\tilde{r}_i, \tilde{r}_j) = (\tilde{r}_i, \tilde{r}_j)\].

- \(r(0, \ell) = (h, \ell)\) with probability \(n\), \(r(0, h) = (\ell, h)\) with probability \(m\).

- If \(\tilde{r}_i = \tilde{r}_j\):
  \[r(\tilde{r}_i, \tilde{r}_j) = (\ell, h)\) or \(r(\tilde{r}_i, \tilde{r}_j) = (h, \ell)\), each with probability \(1/2\).

iv) Each firm \(i\) pays \(F_{ri}\). Firms then simultaneously set prices conditional on attached positions \(p_i(r_i, r_j)\).

v) Uninformed consumers form beliefs \(b((p_i, r_i), (p_j, r_j))\). Each consumer buys the good providing him the higher net utility, or none if both net utilities are negative.

We solve for perfect Bayesian equilibria (PBE), which require strategies to be sequentially rational and beliefs to be consistent on the equilibrium path.

### 3 Conditions for separation

We are looking for a separating equilibrium. Because the actual positions are just labels, we assume without loss of generality that in such an equilibrium \(r_H = h\) and \(r_L = \ell\). Consistent beliefs then require \(b((h, p_H), (\ell, p_L)) = 1\) and \(b((\ell, p_L), (h, p_H)) = 0\). We start defining profits and deviation profits of the pricing game (iv) and then turn to the positioning game (i and ii). Two final subgames exist. The ‘correct’ one where \(r_H = h\) and \(r_L = \ell\), and the ‘wrong’ one where \(r_H = \ell\) and \(r_L = h\).

Sequential rationality requires that both firms play mutual best responses in both of these subgames. We denote best responses in the ‘correct’ subgame as

- \(p^H_H := p_H(h, \ell) \in \arg\max_p \Pi_H[(h, p), (\ell, p_L), b((h, p), (\ell, p_L)), b((\ell, p_L), (h, p))]\) and
- \(p^L_L := p_L(\ell, h) \in \arg\max_p \Pi_L[(\ell, p), (h, p_H), b((\ell, p), (h, p_H)), b((h, p_H), (\ell, p))]\),

and corresponding gross profits as

\[\Pi^H_H = \Pi_H[(h, p^H_H), (\ell, p^L_L), 1, 0] \text{ and } \Pi^L_L = \Pi_L[(\ell, p^L_L), (h, p^H_H), 0, 1]\,.

Equivalently, in the ‘wrong’ subgame best responses and gross profits are

- \(p^H_H = p^L_H \in \arg\max_p \Pi_H[(\ell, p), (h, p_L), b((\ell, p), (h, p_L)), b((h, p_L), (\ell, p))]\) and
- \(p^L_L = p^H_L \in \arg\max_p \Pi_L[(h, p), (\ell, p_H), b((h, p), (\ell, p_H)), b((\ell, p_H), (h, p))]\),
respectively,

\[
\Pi_H^t = \Pi_H[(\ell, p_H^t), (h, p_L^t), b((\ell, p_H^t), (h, p_L^t))], b((h, p_L^t), (\ell, p_H^t))] \text{ and } \\
\Pi_L^h = \Pi_L[(h, p_L^h), (\ell, p_H^h), b((h, p_L^h), (\ell, p_H^h))].
\]

We turn to the positioning game, which is illustrated in Figure 1. Separation requires \(\tilde{r}_L \neq \tilde{r}_H\). Because the intermediary can always set \(F^t = 0\) and/or \(F^h = 0\), it is without loss of generality to assume that \(\tilde{r}_L \neq 0\) and \(\tilde{r}_H \neq 0\) in any candidate equilibrium. We thus denote choices in the separating equilibrium as \(\tilde{r}_L = \ell\) and \(\tilde{r}_H = h\). Expected profits when \(\tilde{r}_L = \ell\) and \(\tilde{r}_H = h\) are then \((\Pi_L^h, \Pi_H^t)\). Expected deviation profits are \((\frac{1}{2}(\Pi_L^l + \Pi_H^t), \frac{1}{2}(\Pi_H^l + \Pi_H^t))\) when deviating to the choice of the competitor \(\tilde{r}_L = \tilde{r}_H\), and \((\Pi_L^0, \Pi_H^0)\) when deviating to \(\tilde{r} = 0\). Clearly we have \(\Pi_i^0 \in [\Pi_i^l, \Pi_i^h]\), because the final gross profit is always either \(\Pi_i^l\) or \(\Pi_i^h\).

\[
\begin{array}{c|c|c}
H \ell & h & \ell & 0 \\
\hline
\frac{1}{2} (\Pi_H^l + \Pi_H^t - F^h - F^t) & \Pi_H^l - F^h & m (\Pi_H^l - F^h) + (1 - m) (\Pi_H^t - F^t) & (1 - m)\Pi_H^l + m\Pi_H^t \\
\frac{1}{2} (\Pi_H^l + \Pi_H^t - F^h - F^t) & \Pi_H^t - F^t & \frac{1}{2} (\Pi_H^l + \Pi_H^t - F^h - F^t) & (1 - n) (\Pi_H^l - F^h) + n (\Pi_H^t - F^t) \\
\frac{1}{2} (\Pi_H^l + \Pi_H^t - F^h - F^t) & \Pi_L^h - F^t & n\Pi_H^l + (1 - n)\Pi_H^t & \frac{1}{2} (\Pi_H^l + \Pi_H^t) \\
\frac{1}{2} (\Pi_H^l + \Pi_H^t - F^h - F^t) & \Pi_L^t - F^t & (1 - n) (\Pi_L^l - F^h) + n (\Pi_L^t - F^t) & \frac{1}{2} (\Pi_H^l + \Pi_H^t) \\
\end{array}
\]

Figure 1: The positioning game.

If \(\tilde{r}_H = h\), then \(\tilde{r}_L = \ell\) is a best response only if \(\Pi_L^t - F^t \geq \Pi_L^h - F^h\). Similarly, \(\tilde{r}_H = h\) is a best response to \(\tilde{r}_L = \ell\) only if \(\Pi_H^t - F^t \geq \Pi_H^h - F^t\). These incentive compatibility constraints set upper and lower bounds for \(F^t\) and \(F^h\). Both conditions can simultaneously hold only if \(\Pi_H^t + \Pi_L^t \geq \Pi_H^h + \Pi_L^h\). The first result states that this condition is also sufficient for a separating equilibrium to exist. All proofs are relegated to the Appendix.

**Proposition 1.** A separating equilibrium exists if and only if \(\Pi_H^t + \Pi_L^t \geq \Pi_H^h + \Pi_L^h\). Prices in this equilibrium are \(p_H^t\) and \(p_L^t\) and fees are \(F^h = \max\{\Pi_H^t - \Pi_H^h, 0\}\) and \(F^t = \max\{\Pi_L^t - \Pi_L^h, 0\}\).

Proposition 1 shows that a separating equilibrium exists, if and only if the aggregate profit is maximized when the ‘correct’ ranking and thus the correct beliefs are imposed. Furthermore, the intermediary can extract at least the whole surplus resulting from displaying the ‘correct’ ranking instead of the ‘wrong’ ranking. In
particular, if both firms benefit from the ‘correct’ ranking, the intermediary can charge a strictly positive fee for both positions.

Charging fees such that both firms ask for the same position is never profitable for the intermediary. It would require the fee to be sufficiently low such that the firm with the lower willingness to pay is willing to pay it. Because only one firm would finally pay the fee, and because it does not matter for the intermediary which one, this can never be beneficial for the intermediary. This would be different in case of proportional fees, or the rule that firms have to pay for the position they asked for. In the first case, because it would matter which firm paid the fee. In the latter case, because both firms might pay the fee. In these alternative settings, the intermediary’s incentive compatibility constraint would therefore not be fulfilled for free.

Proposition 1 simplifies the question of whether or not a separating equilibrium exists. We merely have to check if for a given belief system that is consistent with a putative separating equilibrium, the aggregate profit is maximized if the ‘correct’ or the ‘wrong’ ranking is displayed.

4 Fully informative ranking

We are interested in a separating equilibrium where types are signaled by the position alone. Beliefs of uninformed consumers should therefore not depend on prices, but only on the observed rank position. Hence \( b((h, p_i), (\ell, p_j)) = 1 \) \( \forall p_i, p_j \), and \( b((\ell, p_i), (h, p_j)) = 0 \) \( \forall p_i, p_j \). In this candidate equilibrium, beliefs are homogeneous if the ‘correct’ ranking is imposed. If an agent deviated such that the ‘wrong’ ranking was imposed, beliefs would have to be heterogeneous. Indeed, informed consumers would believe that firm \( H \), being on position \( \ell \), was the high quality firm. Uninformed consumers would believe that firm \( L \), being on position \( h \), was the high quality firm.

We start with the observation that if \( p_H < p_L \) no informed consumer will buy the low quality good. Equally, if \( p_i^h < p_j^\ell \) no uninformed consumer with belief \( b((h, p_i^h), (\ell, p_j^\ell)) = 1 \) will buy from the firm on position \( \ell \). Hence, if uninformed and informed consumers do not share the same belief, there is a discontinuity in the demand function at \( p_H = p_L \).

We denote the firm choosing the weakly lower price as \( A \) and the other one as \( B \), hence \( p_A \leq p_B \). Let \( a \) be the share of consumers believing \( A = H \) and \( 1 - a \) the share believing \( B = H \). All consumers believing \( A \) is the high quality firm will buy from \( A \) as long as \( V \geq p_A \). Consumers believing \( B \) is the high quality firm buy from \( A \) only if their valuation for quality is sufficiently low. These consumers will
however never buy from $A$ if $V < p_A$. In this case $p_B$ does not affect the demand of firm $A$. Hence, firm $A$’s demand is given by

$$D_A(p_A, p_B) = \begin{cases} 
    a + (1 - a)(p_B - p_A) & \text{if } V \geq p_A \\
    a(1 + V - p_A) & \text{if } V < p_A.
  \end{cases}$$

Consumers buy from firm $B$ only if they believe it is the high quality firm and if their valuation for quality is sufficiently high. Demand of firm $B$ is therefore

$$D_B(p_B, p_A) = \begin{cases} 
    (1 - a)(1 + p_A - p_B) & \text{if } V \geq p_A \\
    (1 - a)(1 + V - p_B) & \text{if } V < p_A.
  \end{cases}$$

The optimization problem of firm $i$ is

$$\max_{p_i} \Pi_i = p_i D_i(p_i, p_j).$$

In the proof of Proposition 2 we show that if there is an equilibrium with $p_A < p_B$, it must be that $a \leq \frac{1}{2}$. Hence, if beliefs are homogeneous we have $a = 0$ and $A$ must be the low quality firm. If beliefs are heterogeneous ($a > 0$), then $A$ is the low quality firm when the share of informed consumers is large ($\alpha > \frac{1}{2}$), and the high quality firm if the share of informed consumers is small ($\alpha < \frac{1}{2}$). According to Proposition 1, a separating equilibrium does therefore exist if and only if the aggregate profit when $a = 0$ is not lower than the aggregate profit when $a = \min\{\alpha, 1 - \alpha\}$. Proposition 2 shows that this is the case whenever $V$ is sufficiently low.

**Proposition 2.**

1. The position can never fully reveal quality if $V \geq 1$.

2. If $V \in \left(\frac{1}{3}, 1\right)$, the position can fully reveal quality if the share of informed consumers is sufficiently close to $\frac{1}{2}$ and $V$ is sufficiently small. It can never fully reveal quality if either $V$ is sufficiently high, or the share of informed consumers is close to 1 or 0.

3. The position can fully reveal quality for any share of informed consumers if $V \leq \frac{1}{3}$.

Proposition 2 shows that the ranking cannot fully reveal quality if differentiation between firms is low, while it can, if differentiation is high. To understand this result consider the two opposing effects belief heterogeneity has on the aggregate profit. First, with homogeneous beliefs all consumers with a high valuation for quality buy the good from the high quality firm, which charges a higher price than the low
quality firm. However, this is no longer the case if beliefs are heterogeneous. In this case, some consumers believe that the cheaper good is from the high quality firm. Hence, some high valuation consumers will buy the cheaper good, while low valuation consumers always buy the cheaper good. This effect of belief heterogeneity lowers the aggregate profit. Second, consumers believing the low price firm to be the high quality firm, are never indifferent regarding buying from one or the other firm. Thus, for given prices, elasticity of demand is smaller with heterogeneous beliefs as less consumers are willing to change their purchase decision in response to small price changes. Hence, the low price firm’s demand becomes less elastic, which reduces her incentive to undercut the competitor’s price. This effect increases the aggregate profit. Put differently, heterogeneous beliefs hinder market segmentation, which is negative for the aggregate profit, but also soften competition, which is positive for the aggregate profit.

The competition softening effect dominates when vertical differentiation is low ($V$ large), while the market segmentation effect dominates when vertical differentiation is high ($V$ small). This is intuitive. If vertical differentiation is low, competition is intense and the price difference between firms is relatively small. If differentiation is high, competition between firms is less intense, but the price difference between firms is relatively large. In the first case, softening competition has a large impact on the aggregate profit, while in the latter case, hindering market segmentation has a large (negative) impact on the aggregate profit.

Proposition 2 is illustrated in Figure 2. In region 3, firm $B$ always sets the monopoly price. Then, no competition softening can arise and aggregate profit is higher if beliefs are homogeneous. Hence, a separating equilibrium exists. In re-

![Figure 2: Graphical depiction of the cases described in Proposition 2](image-url)
region 1 and 2a, both firms set a smaller price than the monopoly price. Surprisingly, then the competition softening effect always dominates and no separating equilibrium can exist. In regions 2b and 2c, both prices are below the monopoly price if beliefs are homogeneous, while firm $B$ will choose the monopoly price if beliefs are heterogeneous. The competition softening effect dominates in region 2b, while the market segmentation effect dominates in region 2c. Consequently, a separating equilibrium exists in region 2c, but not in region 2b. Intuitively, incomplete market segmentation is costly if the price gap between firms is large (this is the case if $V$ is small and differentiation therefore high), and/or if heterogeneity is large (this is the case when the share of informed consumers is close to $\frac{1}{2}$).

5 Extension: Pay for the asked position

We now consider the case where firms have to pay for their asked instead of the assigned position. Everything else remains as described in the previous sections.

Proposition 3. A separating equilibrium when firms have to pay the lump sum fees for the position they ask for (and not for the position they get) exists if and only if either $\Pi_h^H + 2\Pi_L^L \geq \Pi_H^H + 2\Pi_h^L$ and $\Pi_h^H \geq \Pi_H^H$, and/or if $2\Pi_h^H + \Pi_L^L \geq 2\Pi_H^L + \Pi_h^L$ and $\Pi_L^L \geq \Pi_h^L$ holds.

It is harder for a separating equilibrium to exist than in the situation where firms have to pay for the realized position. The reason is that if both firms ask for the same position, then both firms have to pay the same fee. This makes it possible that the intermediary benefits from choosing fees such that both firms ask for the same position. Hence, the intermediary’s incentive compatibility constraint is no longer fulfilled for free.

An interesting observation can be made with regards to a situation where profits only depend on the ranking but not on the firms’ types such that $\Pi_h^H = \Pi_L^H$ and $\Pi_h^L = \Pi_L^L$. Then, a separating equilibrium exists under this rule only if the profit on both positions is the same. Consequently, the intermediary could never charge a positive fee. That is in sharp contrast to Hertzendorf & Overgaard (2001) and Fluet & Garella (2002). In these settings, a firm’s incentive to pay for advertisement becomes smaller if the competing firm advertises. Advertising is a strategic substitute. In the symmetric case, where ex ante both firms benefit in the same way from advertising, a separating equilibrium therefore exists. In our setting, exactly the opposite is the case. Paying for visibility is a strategic complement. The willingness to pay for visibility increases, when the competing firm pays for it. Therefore, in the symmetric
case, where ex-ante both firms benefit in the same way from visibility, no separating equilibrium exists.

Revisiting the setting from section 4, the next result shows the implications of Proposition 3 in our setup.

**Proposition 4.** When firms have to pay for the position they ask for, then:

- The rank can never fully reveal quality if $\alpha < \frac{1}{2}$.
- The rank can fully reveal quality if $\alpha$ is sufficiently high and $V \leq \frac{1}{3}$.

Proposition 4 shows that a separating equilibrium only exists if the share of informed consumers is high. If $\alpha < 0.5$, then $\Pi_h^L$ is relatively high. It is therefore difficult for the condition to hold. The intuition for this result is as follows. The intermediary’s incentive to choose fees such that both firms pool is high if the low type’s willingness to pay for the high position is high. This is the case when the share of informed consumers ($\alpha$) is small. Hence, if $\alpha$ is small, no separating equilibrium can exist because the intermediary benefits from choosing pooling fees.

### 6 Conclusion

We have shown under which conditions positions in a list can serve as a signal for the quality of an experience good, if competing firms can pay for it. We have derived two key results. First, given that consumers trust the ranking, this kind of signaling is possible if and only if the ‘correct’ ranking maximizes industry profit. Second, the ‘correct’ ranking maximizes industry profit if firms are sufficiently differentiated. Consequently, positions can signal quality if the quality differentiation between firms is high, but not if differentiation is low.

This provides an explanation why some positions in a search list might be ‘better’ than others in case of experience goods. The condition for signaling to work is however very strict. This does partly rely on our extreme equilibrium refinement. We assumed that beliefs only depend on the displayed position, but not on the price. It would be an interesting extension to allow the price to contain information as well. If differentiation between firms is low, prices alone cannot signal quality as shown by Hertzendorf & Overgaard (2001) and Fluet & Garella (2002). It is therefore not clear, whether or not a price-rank combination could do so.

The effect of other possible extensions is more straightforward. First, with more than two firms, a separating equilibrium would still require the aggregate profit under the ‘correct’ ranking (and therefore ‘correct’ beliefs) to be higher than under every other ranking (with ‘wrong’ beliefs). The necessary condition would therefore
look similar to the condition in Proposition 1. Second, it is standard to think about marginal cost being positively correlated with a firm's quality. In our model this would make a separating equilibrium harder to exist, because under ‘correct’ beliefs, it is the high quality firm which faces a higher demand in equilibrium.
A Proofs

A.1 Proof of Proposition 1

Only if: Follows directly from the text.

If: We have to make a case distinction. The necessary condition implies that either:

(A) \( \Pi_h^h \geq \Pi_h^\ell \) and \( \Pi^\ell_L \geq \Pi_L^h \);

(B) \( \Pi_h^h > \Pi_h^\ell \) and \( \Pi^\ell_L \leq \Pi_L^h \);

(C) \( \Pi_h^h \leq \Pi_h^\ell \) and \( \Pi^\ell_L > \Pi_L^h \).

Recall the assignment rule in case one firm reports \( \hat{r}_i = 0 \): \( r(0, h) = (\ell, h) \) with probability \( m \), \( r(0, \ell) = (h, \ell) \) with probability \( n \).

\( \hat{r}_L, \hat{r}_H \neq 0 \) requires both

\[ \Pi^\ell_L - F^\ell \geq m\Pi^\ell_L + (1 - m)\Pi_L^h \]

(I\(R_L\))

and

\[ \Pi^h_H - F^h \geq (1 - n)\Pi_h^\ell + n\Pi^h_H \]

(I\(R_H\))

to hold. Hence

\[ \Pi_I = F^\ell + F^h \leq (1 - m)(\Pi^\ell_L - \Pi_L^h) + (1 - n)(\Pi_h^\ell - \Pi^h_H). \]

The intermediary’s maximal profit if \( \hat{r}_L, \hat{r}_H \neq 0 \) (obtained by optimally choosing \( n \) and \( m \)) in the different situations is therefore

(A) \( \Pi_I = \Pi^\ell_L - \Pi_L^h + \Pi_h^\ell - \Pi^\ell_H \);

(B) \( \Pi_I = \Pi_h^\ell - \Pi^\ell_H \);

(C) \( \Pi_I = \Pi^\ell_L - \Pi^\ell_H \).

The intermediary’s maximal profit if either \( \hat{r}_L = 0 \) or/and \( \hat{r}_H = 0 \), is equivalent to setting either \( F^\ell = 0 \) or/and setting \( F^h = 0 \). We show that a separating equilibrium where \( \hat{r}^*_L \neq \hat{r}^*_H \) and \( r(\hat{r}^*_L, \hat{r}^*_H) = (\ell, h) \) exists, where these profits can be achieved. In

(A) \( F^\ell = \Pi^\ell_L - \Pi_L^h, \quad F^h = \Pi_h^\ell - \Pi^\ell_H, \quad m = n = 0 \); in (B) \( F^\ell = 0, \quad F^h = \Pi_h^\ell - \Pi^\ell_H, \quad m = 1, n = 0 \); in (C) \( F^\ell = \Pi^\ell_L - \Pi_L^h, \quad F^h = 0, \quad m = 0, n = 1 \). It is straightforward to check that \( (\hat{r}^*_L, \hat{r}^*_H) \) are then indeed mutual best responses and that the profit is maximized. \( \square \)
A.2 Proof of Proposition 2

The proof consists of a succession of claims, that together establish the result.

Claim 1. If \( a \leq \frac{1}{2} \) then \( p_A \leq p_B \) in equilibrium.\(^6\)

Proof. Suppose not, i.e. assume \( a \leq 0.5 \) and \( p_A > p_B \).

- \( p_A \leq 1 \) must hold in equilibrium, because otherwise \( A \) could always profit from lowering the price by a sufficiently low amount \( \varepsilon \), (such that \( p_A - \varepsilon > p_B \)) because then
  \[
  \Pi_A(p_A - \varepsilon, p_B) - \Pi_A(p_A, p_B) = p_Aa\varepsilon - a\varepsilon(1 + p_B - p_A + \varepsilon) > 0,
  \]

- Consider the case where \( p_A \leq V \). Then \( B \)'s profit when \( p_B < p_A \) is \( \Pi_A(p_B < p_A, p_A) = p_B((1 - a) + a(p_A - p_B)) \). By choosing \( p_B = p_A \) her profit would however be \( \Pi_A(p_B = p_A, p_A) = p_A(1 - a) \), and therefore (strictly) larger when \( a \leq (\leq)\frac{1}{2} \) and \( p_A \leq 1 \).

Consequently, if \( p_A \leq V \), \( p_B < p_A \) cannot happen in equilibrium.

- In case \( p_A \geq V \) and \( p_B < V \), \( B \)'s profit when \( p_B < p_A \) is \( \Pi_B(p_B < p_A, p_A) = p_B((1 - a) + a(p_A - p_B)) \). By choosing \( p_B = V \) her profit would however be \( \Pi_A(p_B = p_A, p_A) = V(1 - a) \), and therefore (strictly) larger when \( a \leq (\leq)\frac{1}{2} \) and \( p_A \leq 1 \).

- If \( p_A \geq V \) and \( p_B \geq V \), prices do not depend on \( a \) and are \( p_A = p_B = \frac{1+V}{2} \).

\[ \square \]

Claim 2. If \( p_A \leq V \), then \( a \leq \frac{1}{2} \).

Proof. Because of symmetry, the above claim also implies that \( p_B \leq p_A \) if \( a \geq 0.5 \) and the claim must hold.

\[ \square \]

Claim 3. If \( V \geq \frac{1+a}{3(1-a)} \), then \( p_A = \frac{1+a}{3(1-a)} \leq V \) in equilibrium.

Proof. Under the assumption that \( p_A \leq V \), best responses are calculated as \( p_A(p_B) = \frac{a+(1-a)p_B}{2(1-a)} \) and \( p_B(p_A) = \frac{1+p_A}{2} \). Prices in the putative equilibrium are then \( p_A = \frac{1+a}{3(1-a)} \) and \( p_B = \frac{2-a}{3(1-a)} \). Those equations thus characterize optimal prices if and only if \( V \geq \frac{1+a}{3(1-a)} \).

\[ \square \]

\(^6\)In all Claims we assume that a separating equilibrium exists and derive properties that must then be true.
Claim 4. If $V < \frac{1+a}{3(1-a)}$, then $p_A$ is either $p_A = V$ or $p_A = \frac{1+V}{2} > V$.

Proof. A’s profit when choosing a price $p_A \leq V$ is $p_A (a + (1 - a)(p_B - p_A))$ and strictly increasing in $p_A$ as long as $p_B \geq \frac{1+V}{2}$, which is always true if $p_A \leq V$. If $p_A > V$, A cannot attract any consumers who believes A is the low type. Consequently, she will set the monopoly price with respect to those consumers, believing she is the high type. A’s optimal price must therefore be either $p_A = V$ or the monopoly price $p_A = \frac{1+V}{2}$. A’s profit is therefore $V (a + (1 - a)\frac{1-V}{2})$ when $p_A = V$ and $a \left(\frac{1+V}{2}\right)^2$ if $p_A > V$.

Claim 5. The industry profit is strictly increasing in $a$ if $V \geq \frac{1+a}{3(1-a)}$.

Proof. Using the prices from Claim 3, the industry profit is calculated as

$$\Pi_A + \Pi_B = \frac{(1+a)^2}{9(1-a)} + \frac{(2-a)^2}{9(1-a)},$$

and therefore strictly increasing in $a$.

Claim 6. The industry profit is maximized for $a = 0$ if $V < \frac{1+a}{3(1-a)}$.

Proof. From Claim 4, the optimal price is either $p_A = V$ or the monopoly price, so the following case distinction is needed:

- If $a \leq \frac{2V(1-V)}{1-V^2}$, the profit when $p_A = V$ is larger. In that case $p_B = \frac{1+V}{2}$ the and industry profit is

  $$\Pi_A + \Pi_B = V \left(a + (1-a)\frac{1-V}{2}\right) + (1-a) \left(\frac{1+V}{2}\right)^2,$$

  and therefore strictly decreasing in $a$ because $V < 1$ (otherwise we are in Case 1).

- If $a > \frac{2V(1-V)}{1-V^2}$, the optimal price is $p_A = \frac{1+V}{2}$. In that case $p_B = \frac{1+V}{2}$ and the industry profit is

  $$\Pi_A + \Pi_B = \left(\frac{1+V}{2}\right)^2,$$

  This industry profit is strictly smaller than the profit when $a = 0$, which is

  $V \frac{1-V}{2} + \left(\frac{1+V}{2}\right)^2$. 

\[\square\]
If $V \geq 1$ (region 1) Claim 3 applies whereas Claim 4 applies if $V \leq \frac{1}{3}$ (region 3). If $V \in (\frac{1}{3}, 1)$ depending on $a$, either case might apply. We are at the interior solution of Claim 3 when $a$ is sufficiently low and at the corner or monopoly solutions of Claim 4 otherwise. Thus, if beliefs are homogeneous ($a = 0$) the industry profit is

$$\Pi_A + \Pi_B = \frac{5}{9}.$$  

In case $a$ is not too high with heterogeneous beliefs, $V \geq \frac{1+a}{3(1-a)}$ (region 2a) still holds (Claim 3 applies) and the industry profit is then higher with heterogeneous beliefs than with homogeneous beliefs. If $a$ is sufficiently high with heterogeneous beliefs such that $V < \frac{1+a}{3(1-a)}$, industry profit is either (Claim 4):

$$\Pi_A + \Pi_B = V \left(a + (1-a)\frac{1-V}{2}\right) + (1-a)\left(\frac{1+V}{2}\right)^2,$$

or

$$\Pi_A + \Pi_B = \left(\frac{1+V}{2}\right)^2.$$

Both of these profits are smaller than $\frac{5}{9}$ if $V$ is sufficiently small (region 2c), and larger than $\frac{5}{9}$ if $V$ is sufficiently high (region 2b). The profit with homogeneous beliefs ($a = 0$) is in this case therefore larger than the profit with heterogeneous beliefs if $V$ is sufficiently small (sufficiently close to $\frac{1}{3}$) and smaller than the profit with heterogeneous beliefs if $V$ is sufficiently large (close to 1). That is, if $V$ is close to 1 and the share of informed consumers is close to $\frac{1}{2}$.

### A.3 Proof of Proposition 3

**Only if:** As in the previous case, firms’ incentive compatibility constraints hold iff $\Pi^h_H + \Pi^L_L \geq \Pi^H_H + \Pi^L_L$.

Consider the case where $\Pi^h_H > \Pi^L_H$ and $\Pi^L_L \geq \Pi^L_L$ and assume that the condition does not hold, that is, $\Pi^h_H + 2\Pi^L_L < 2\Pi^H_H + \Pi^L_L$. We show that the Intermediary then has an incentive to set fees such that both firms ask for the same position. First, $\tilde{r}_L = \ell$ requires $\Pi^L_L - F^\ell \geq m\Pi^L_L + (1-m)\Pi^L_L$, and therefore $F^\ell \leq 0$. Second, $\tilde{r}_H \neq \ell$ requires $\Pi^h_H - F^h \geq \frac{1}{2} \left(\Pi^h_H + \Pi^L_H - F^\ell\right)$, and therefore $F^h \leq \frac{1}{2} \left(\Pi^h_H - \Pi^L_H\right)$. The intermediaries profit is therefore

$$\Pi_I = F^\ell + F^h \leq \frac{1}{2} \left(\Pi^h_H - \Pi^L_H\right).$$

Consider the fees $F_L > 0$ and $F_H = \frac{1}{2}(\Pi^L_L - \Pi^L_L)$ and the assignment rule $r(0, h) = (\ell, h)$ (that is $m = 1$). Then both firms would choose $\tilde{r} = h$ (note that $IR_H$ holds because $\Pi^h_H - \Pi^L_H \geq \Pi^L_L - \Pi^L_L$). The intermediary’s profit in this pooling case is

$$\Pi_I = 2F^h = \Pi^L_L - \Pi^L_L > \frac{1}{2} \left(\Pi^h_H - \Pi^L_H\right).$$
Hence, the intermediary would benefit from choosing fees such that firms pool. The case where $\Pi^h_H > \Pi_L^h$ and $\Pi_L^h \geq \Pi^h_H$ works equivalently.

If: From the previous part we again have $\Pi^h_H + \Pi_L^f \geq \Pi^h_H + \Pi_L^L$, and therefore three different cases.

(A) $\Pi^h_H \geq \Pi^f_H$ and $\Pi_L^f \geq \Pi^h_L$.

(B) $\Pi^h_H > \Pi^f_H$ and $\Pi_L^f \leq \Pi^h_L$.

(C) $\Pi^h_H \leq \Pi^f_H$ and $\Pi_L^f > \Pi^h_L$.

We show that a separating equilibrium where $\tilde{r}_L^* \neq \tilde{r}_H^*$ and $r(\tilde{r}_L^*, \tilde{r}_H^*) = (\ell, h)$ exists. In (A) $F^f = \frac{1}{2} (\Pi_L^f - \Pi_L^h)$, $F^h = \frac{1}{2} (\Pi_H^h - \Pi_H^f)$, $m = n = 0$; in (B) $F^f = 0$, $F^h = \frac{1}{2} (\Pi_H^h - \Pi_H^f)$, $m = 1, n = 0$; in (C) $F^f = \frac{1}{2} (\Pi_L^f - \Pi_L^h)$, $F^h = 0$, $m = 0, n = 1$. It is straightforward to check that $(\tilde{r}_L^*, \tilde{r}_H^*)$ are then indeed mutual best responses. The profit is maximized because the intermediary’s maximal profit if either $\tilde{r}_L = 0$ or/and $\tilde{r}_H = 0$, is equivalent to setting either $F^f = 0$ or/and setting $F^h = 0$. Moreover, by the first part of the proof, the intermediary’s profit cannot be higher when setting fees such that $\tilde{r}_L = \tilde{r}_H$. Finally, setting fees such that $\tilde{r}_L \neq \tilde{r}_H$ and $r(\tilde{r}_L^*, \tilde{r}_H^*) = (h, \ell)$ is only possible if $\Pi^h_H = \Pi_L^h$ and $\Pi_L^f = \Pi_L^f$. But then, all fees must be 0.

\[ \square \]

\section*{A.4 Proof of Proposition 4}

The condition in Proposition 3 can never hold if the condition in Proposition 1 does not hold. We therefore only have to consider region 2.c and region 3.

Case 1 $\alpha < \frac{1}{2}$: In region 2.c, profits are as described in Claim 5 if $a = 0$ and as described in Claim 6 if $a > 0$.

- If $a = 0$, then by Claim 5: $\Pi_H^h = \Pi_B = \frac{\alpha}{5}$ and $\Pi_L^f = \Pi_A = \frac{\alpha}{9}$ and therefore $\Pi_H^h + 2\Pi_L^f = \frac{2}{3}$.

- If $a > 0$ we have $a = \alpha$, then by Claim 6: $\Pi_H^h = \Pi_B = (1 - \alpha) \left(\frac{1+V}{2}\right)^2$ and $\Pi_L^f = \Pi_A \geq \alpha \left(\frac{1+V}{2}\right)^2$ and therefore $\Pi_H^f + 2\Pi_L^f \geq (2 - \alpha) \left(\frac{1+V}{2}\right)^2$.

But this violates the condition because $\Pi_H^f + 2\Pi_L^f = \frac{2}{3} < (2 - \alpha) \left(\frac{1+V}{2}\right)^2 \leq 2\Pi_L^f + \Pi_H^f$.

In region 3, profits are as described in Claim 6.

- If $a = 0$: $\Pi_H^h = \Pi_B = (1 + V)^2$, $\Pi_L^f = \Pi_A = V \frac{1-V}{2}$ and therefore $\Pi_H^f + 2\Pi_L^f = \left(\frac{1+V}{2}\right)^2 + V(1-V)$.

- If $a > 0$ we have $a = \alpha$: $\Pi_H^h = \Pi_B = (1 - \alpha) \left(\frac{1+V}{2}\right)^2$ and $\Pi_H^f = \Pi_A \geq \alpha \left(\frac{1+V}{2}\right)^2$ and therefore $\Pi_H^f + 2\Pi_L^f \geq (2 - \alpha) \left(\frac{1+V}{2}\right)^2$.
Again, this violates the condition because $\Pi^h_H + 2\Pi^l_L = (\frac{1+V}{2})^2 + V(1 - V) < (2 - \alpha)(\frac{1+V}{2})^2 \leq 2\Pi^h_H + \Pi^l_H$.

**Case 2 $\alpha > \frac{1}{2}$:** In region 2.c, profits are as described in Claim 5 if $a = 0$ and as described in Claim 6 if $a > 0$.

- If $a = 0$, then by Claim 5: $\Pi^h_H = \Pi_B = \frac{4}{9}$ and $\Pi^l_L = \Pi_A = \frac{1}{9}$ and therefore $\Pi^h_H + 2\Pi^l_L = \frac{2}{3}$.

- If $a > 0$ we have $a = 1 - \alpha$, then by Claim 6: $\Pi^h_H = \Pi_B = \alpha (\frac{1+V}{2})^2$, $\Pi^l_L = \Pi_A = \text{max}\left\{ V \left( (1 - \alpha) + \alpha \frac{1-V}{2} \right), (1 - \alpha) (\frac{1+V}{2})^2 \right\}$, where
  
  $V \left( (1 - \alpha) + \alpha \frac{1-V}{2} \right) > (1 - \alpha) (\frac{1+V}{2})^2$ if $\alpha$ is sufficiently high. In this case we therefore have $\Pi^h_H + 2\Pi^l_L = \alpha (\frac{1+V}{2})^2 + 2V(1 - \alpha) + \alpha V(1 - V)$.

But then the condition always holds if $\alpha$ is sufficiently high and $V$ sufficiently small (close to $\frac{1}{3}$) because then $\Pi^h_H + 2\Pi^l_L = \frac{2}{3} \geq \alpha (\frac{1+V}{2})^2 + 2V(1 - \alpha) + \alpha V(1 - V) = \Pi^h_H + 2\Pi^l_L$.

In region 3 ($V \leq \frac{1}{3}$) profits are as described in Claim 6.

- If $a = 0$: $\Pi^h_H = \Pi_B = (\frac{1+V}{2})^2$, $\Pi^l_L = \Pi_A = V \frac{1-V}{2}$ and therefore $\Pi^h_H + 2\Pi^l_L = (\frac{1+V}{2})^2 + V(1 - V)$.

- If $a > 0$ we have $a = 1 - \alpha$: $\Pi^h_H = \Pi_B = \alpha (\frac{1+V}{2})^2$, $\Pi^l_L = \Pi_A = \text{max}\left\{ V \left( (1 - \alpha) + \alpha \frac{1-V}{2} \right), (1 - \alpha) (\frac{1+V}{2})^2 \right\}$, where
  
  $V \left( (1 - \alpha) + \alpha \frac{1-V}{2} \right) > (1 - \alpha) (\frac{1+V}{2})^2$ if $\alpha$ is sufficiently high. In this case we therefore have $\Pi^h_H + 2\Pi^l_L = \alpha (\frac{1+V}{2})^2 + 2V(1 - \alpha) + \alpha V(1 - V)$.

But then the condition always holds if $V \leq \frac{1}{3}$ because then $\Pi^h_H + 2\Pi^l_L = (\frac{1+V}{2})^2 + V(1 - V) \geq \alpha (\frac{1+V}{2})^2 + 2V(1 - \alpha) + \alpha V(1 - V) = \Pi^h_H + 2\Pi^l_L$. 

□
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