

# Information Economics

## Signaling Quality through Specialization

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# Road map

- ▶ **Introduction.**
- ▶ Model.
- ▶ Signaling by prices.
- ▶ Signaling by prices and specialization.

# Specialization

- ▶ We see **specialization** for some firms.
  - ▶ “Paint and wallpaper specialists” vs. “carpentry, paint, and landscaping services providers”.
  - ▶ “We do it all” vs. “brake people”.
- ▶ By specializing rather than providing a **product mix**, some potential profits go away.
  - ▶ When there is a synergy among multiple products/services.
  - ▶ Economies of scale.
  - ▶ Complementarity among products/services.
- ▶ Why?
  - ▶ Sometimes they have no choice: technology or capacity constraints.
  - ▶ Sometimes specialization enhances quality or reduces costs.
  - ▶ Any other reason?

## Specialization as a signaling device

- ▶ Kalra and Li (2008) shows that a firm may **signal its hidden quality** through **specialization**.<sup>1</sup>
- ▶ This is especially true for **effort-intensive** areas.
  - ▶ Specialization enhances quality or reduces costs.
  - ▶ Quality varies a lot for different services.
  - ▶ Consumers are quite uncertain about the quality.
- ▶ It may be beneficial to specialize.
  - ▶ In the **secondary category**, I lose some profit.
  - ▶ However, I also save some costs.
  - ▶ Moreover, I earn more in the **primary category** because consumers know that my quality is high.

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<sup>1</sup>Karla, A. and S. Li, 2008, “Signaling quality through specialization,” *Marketing Science* **27**(2), 168–184.

## Key intuitions

- ▶ Is a separation really possible?
- ▶ Suppose there are two firms, one's quality is high and one's is low.
- ▶ Consumers cannot tell whose quality is high. They pay an average price for both services.
  - ▶ The high-quality firm tries to signal to win higher payments.
  - ▶ Why the low-quality firm chooses not to **mimic** the high-type one?
- ▶ Offering a low-quality service incurs a **low service cost**.
  - ▶ The **cost reduction** from specialization is low.
  - ▶ The **opportunity cost** of giving up a category is high.
- ▶ The **cost of specialization** is higher for the low-quality firm. It is **too costly** for a low-quality firm to specialize.

## Pricing and specialization

- ▶ No matter a firm specializes or not, it has the **pricing decision**.
- ▶ A firm may **signal through prices** only.
  - ▶ The high-quality firm charges higher prices.
- ▶ A firm may at the same time **signal through specialization**.
  - ▶ Specialization serves as a **complement** to the price signal.
  - ▶ It helps the high-quality firm to further differentiate itself.
- ▶ Other signaling devices (not discussed here):
  - ▶ Advertising, umbrella branding, retailer reputation, money back guarantees, slotting allowance, warranties, salesforce compensation, etc.

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# Firms

- ▶ There is a firm facing two **categories**, categories 1 and 2.
  - ▶ The firm is able to enter both categories at the same time.
  - ▶ It may also **specialize** in only category 1.
  - ▶ The demands for the two categories are **independent**.
- ▶ The firm's quality may be either **high or low** (label:  $h$  or  $l$ ).
  - ▶ **High in both** categories or **low in both** categories.

## Costs and prices

- ▶ Serving multiple markets (label:  $m$ ) or specializing in one market (label:  $s$ ) require different **unit service costs**.
- ▶ If multiple services are offered:
  - ▶  $C_{im}^j$  = unit cost of service  $i \in \{1, 2\}$  if the quality is  $j \in \{l, h\}$ .
  - ▶  $C_{im}^h > C_{im}^l$  for  $i = 1, 2$ .
- ▶ If a single service is offered:
  - ▶  $C_{1s}^j$  is the unit cost for category 1 if the quality is  $j$ .
- ▶  $C_{1m}^j = \alpha C_{1s}^j$  where  $\alpha > 1$ : There is a **cost reduction** for specialization.
- ▶ **Unit prices** for the two categories are chosen by the firm.
  - ▶  $P_{im}^j$  = price of service  $i \in \{1, 2\}$  offered by the firm of type  $j \in \{l, h\}$ .
  - ▶  $P_{1s}^j$  = price of service 1 offered by the specializing firm of type  $j \in \{l, h\}$ .

## Demands

- ▶ The consumer's willingness-to-pay of service  $i$  is  $\theta_i$ ,  $i \in \{1, 2\}$ .
  - ▶  $\theta_1 \sim \text{Uni}(0, 1)$  and  $\theta_2 \sim \text{Uni}(0, \delta)$ .
  - ▶  $\delta$  may be greater than, equal to, or less than 1.
- ▶ The consumer's utility is  $U_i^j = \theta_i q_i^j - P_i^j$  for buying service  $i$  from a type- $j$  firm.
  - ▶ This can be evaluated if the quality is **public** or the two types of firm play a **separating equilibrium**.
  - ▶ If the consumer cannot tell the quality, he buys the product if the expected utility  $\theta_i[\lambda q_i^h + (1 - \lambda)q_i^l] - P_i \geq 0$ .  $\lambda$  is the **prior belief**.
- ▶ Given a price  $P$  for a service, the **demand** is  $D = 1 - \frac{P}{Q}$ ,<sup>2</sup> where  $Q$  is the quality (under a separation) or expected quality (under pooling).
- ▶ The **profit** in that category is  $\Pi = D(P - C)$ .<sup>3</sup>
- ▶ The firm can always make money in either category.

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<sup>2</sup>Or  $\delta - \frac{P}{Q}$  for category 2.

<sup>3</sup>Proper indices are needed for  $\Pi_{i,t}^j$ ,  $j \in \{l, h\}$ ,  $i \in \{1, 2\}$ ,  $t \in \{s, m\}$ .

# Timing

- ▶ The sequence of events is as follows:
  - ▶ Nature selects the firm's quality according to the prior  $\lambda$ .
  - ▶ The firm decides whether to enter both categories or just category 1.
  - ▶ The firm determines the price(s).
  - ▶ The consumer observes the number of categories entered and the price(s).
  - ▶ He forms the posterior belief  $\Lambda$  on the quality.
  - ▶ He decides whether to buy.
- ▶ We look for **pure-strategy** equilibria.
  - ▶ We will only discuss **separating equilibria**.<sup>4</sup>

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<sup>4</sup>Keep in mind that pooling equilibria are still possible in most cases.

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## Benchmark: complete-information case

- ▶ Suppose the quality is **observable**.
- ▶ Because the firm is able to earn money in either category, under a mild condition (what?), the firm will serve both categories.
- ▶ In categories 1 and 2, the firm of quality  $j$  solves

$$\max_P \left(1 - \frac{P}{q_1^j}\right) (P - \alpha C_{1s}^j) \quad \text{and} \quad \max_P \left(\delta - \frac{P}{q_2^j}\right) (P - \alpha C_{2s}^j)$$

The **first-best prices** are

$$P_{1m}^{j*} = \frac{q_1^j + \alpha C_{1s}^j}{2} \quad \text{and} \quad P_{2m}^{j*} = \frac{\delta q_2^j + \alpha C_{2s}^j}{2}.$$

- ▶ The first-best profit is  $\Pi_m^{j*} = \frac{(q_1^j + \alpha C_{1s}^j)^2}{4q_1^j} + \frac{(\delta q_2^j + \alpha C_{2s}^j)^2}{4q_2^j}$ .

## Signaling through prices only

- ▶ When qualities are unobservable, the first-best prices are suboptimal.
  - ▶ Fewer consumer will be willing to pay those amounts.
  - ▶ If the firm does not try to signal its quality, it should decrease the prices.
- ▶ Suppose the firm still wants to serve both categories.
- ▶ Can **prices along** signal the qualities?

## Profit functions

- ▶ In a **separating** equilibrium, let

$$\Pi_{ma}^t(P_1^t, P_2^t) = \left(1 - \frac{P_1^t}{q_1^t}\right)(P_1^t - \alpha C_{1s}^t) + \left(\delta - \frac{P_2^t}{q_2^t}\right)(P_2^t - \alpha C_{2s}^t)$$

be the type- $t$  firm's profit under prices  $P_1^t$  and  $P_2^t$ ,  $t \in \{l, h\}$ .

- ▶ Denote  $(P_{1ma}^l, P_{2ma}^l)$  and  $(P_{1ma}^h, P_{2ma}^h)$  as the optimal prices for the low- and high-quality firms **under separation**, respectively.
  - ▶ Naturally, they cannot be identical.

## Pricing problems

- ▶ Let  $\Pi_{ma}^{l*} = \Pi_{ma}^l(P_{1ma}^{l*}, P_{2ma}^{l*})$  and  $\Pi_{ma}^{h*} = \Pi_{ma}^h(P_{1ma}^{h*}, P_{2ma}^{h*})$ .
- ▶ In a separating equilibrium, we have for the high-quality firm

$$\begin{aligned}
 (P_{1ma}^{h*}, P_{2ma}^{h*}) &= \operatorname{argmax}_{P_1, P_2} \Pi_{ma}^h(P_1, P_2) \\
 \text{s.t.} \quad \Pi_{ma}^l(P_1, P_2) &\leq \Pi_{ma}^l(P_{1ma}^{l*}, P_{2ma}^{l*}) \\
 \Pi_{ma}^h(P_{1ma}^{l*}, P_{2ma}^{l*}) &\leq \Pi_{ma}^h(P_1, P_2).
 \end{aligned}$$

and for the low-quality firm

$$\begin{aligned}
 (P_{1ma}^{l*}, P_{2ma}^{l*}) &= \operatorname{argmax}_{P_1, P_2} \Pi_{ma}^l(P_1, P_2) \\
 \text{s.t.} \quad \Pi_{ma}^h(P_1, P_2) &\leq \Pi_{ma}^h(P_{1ma}^{h*}, P_{2ma}^{h*}) \\
 \Pi_{ma}^l(P_{1ma}^{h*}, P_{2ma}^{h*}) &\leq \Pi_{ma}^l(P_1, P_2).
 \end{aligned}$$

## Separating equilibrium

- ▶ The following lemma characterize the separating equilibrium.

### Lemma 1

*Suppose the firm must enter both categories. In the separating equilibrium, the high-quality firm distorts prices upwards in both categories. The low-quality firm, on the other hand, chooses its first-best prices.*

- ▶ Prices alone can signal quality.
  - ▶ This conclusion is made due to the existence of a separating equilibrium.
- ▶ **Price distortions** are required.
  - ▶ Why is there a distortion?
  - ▶ Why is it an upward distortion?

## Intuitions for signaling through prices

- ▶ If the high-quality firm charges the first-best prices, the low-quality firm will mimic it by charging the same prices.
- ▶ Therefore, the high-quality firm **upwards distorts** its prices.
  - ▶ This decreases the demands both for the high-quality firm and the low-quality firm mimicking the high-quality one.
- ▶ However, the low-quality firm is **hurt more** due to its **lower costs**.
  - ▶ When the prices are high enough, the low-quality firm will give up.
  - ▶ It will **admit its low quality** and charge its first-best prices. This is optimal for it (even if the low quality is revealed).

## Impacts of signaling through prices

- ▶ If we look at this game from outside:
  - ▶ There is **just one** firm!
  - ▶ Under complete information, the firm charges some prices.
  - ▶ Under incomplete information, the **prices may become higher**.
  - ▶ “My quality (and cost) is high, otherwise I will not charge such a high price.”
  - ▶ Information asymmetry causes **inefficiency**.
- ▶ It is still possible for the prices to eventually become lower (in pooling equilibria).

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## Signaling also through specialization

- ▶ Is it possible to also signal through **specialization**?
  - ▶ “Also”: There is still the pricing decision.
- ▶ In a separating equilibrium, we will see:
  - ▶ The high-quality firm **specializes** in category 1.
  - ▶ The low-quality firm serves both categories.
- ▶ Let

$$\Pi_s^h(P) = \left(1 - \frac{P}{q_1^h}\right)(P - C_{1s}^h)$$

be the type- $h$  firm's profit under price  $P$  in a **separating** equilibrium.

## Signaling also through specialization

- ▶ In a separating equilibrium, we have for the high-quality firm

$$\begin{aligned} \max_P \quad & \Pi_s^h(P) \\ \text{s.t.} \quad & \Pi_s^l(P) \leq \Pi_m^l(P_{1m}^{l*}, P_{1m}^{l*}) \\ & \Pi_{ma}^{h*} \leq \Pi_s^h(P). \end{aligned}$$

- ▶ The low-type firm finds it suboptimal to **mimic** the high-type one.
- ▶ The high-type firm finds it suboptimal to **serve two categories** and earn  $\Pi_{ma}^{h*}$  under signaling **with prices alone**.
- ▶ The problem of the low-quality firm is omitted.
- ▶ Note that due to the second constraint, the firm **earns more** by using specialization as another signaling device.
  - ▶ Be careful! The firm is better off in “this separating equilibrium” than in “that separating equilibrium”.
  - ▶ If we also consider pooling equilibria, specialization may be suboptimal.

## Separating equilibrium

- ▶ The following proposition characterize the separating equilibrium.

### Lemma 2

*There exists a separating equilibrium in which the high-quality firm specializes and upwards distorts the price. The upward distortion is less than that when signaling only through prices. The low-quality firm enters both categories and chooses its first-best prices.*

- ▶ Prices and specialization can **together** signal quality.
- ▶ **An upward price distortion** is still required.
  - ▶ Why the distortion becomes **smaller**?

## Intuitions for a smaller distortion

- ▶ Previously, upward price distortions are used to discourage the low-quality firm from mimicking the high-quality one.
  - ▶ This is possible because the low-quality firm **hates high prices**.
- ▶ Now, the high-quality firm specializes.
  - ▶ The low-quality firm also **hates specialization**: It must give up the profit in category 2.
  - ▶ The upward price distortion needs not to be that much.
- ▶ When will we see specialization?
  - ▶ When the market of the second category is small (i.e.,  $\delta$  is small).
  - ▶ When price sensitivity is high (so large price distortions are harmful).
  - ▶ When consumers are not confident about the quality (i.e.,  $\lambda$  is small).