IM 7011: Information Economics

Lecture 15: Signaling
Kalra and Li (2008)

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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**.
- Possible signaling devices:
  - Prices, advertising, umbrella branding, retailer reputation, money back guarantees, slotting allowance, warranties, salesforce compensation, etc.
- 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.

Key intuitions

- Is a separation really possible?
- It must be **too costly** for a low-quality firm to specialize.
- 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.

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.

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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 θ_i, $i \in \{1, 2\}$.
  - $\theta_1 \sim \mathrm{Uni}(0, 1)$ and $\theta_2 \sim \mathrm{Uni}(0, \delta)$.
  - δ may be greater than, equal to, or less than 1.
- The consumer's utility of buying service i from a type-j firm is

$$U_i^j = \theta_i q_i^j - P_i^j.$$

  - 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 $\theta_i[\lambda q_i^h + (1 - \lambda) q_i^l] - P_i^j \geq 0$. λ is the **prior belief**.
- Given a price P for a service, the **demand** is $D = 1 - \frac{P}{Q}$,[1] where Q is the quality (under a separation) or expected quality (under pooling).
- The **profit** in that category is $\Pi = D(P - C)$.
  - Proper indices are needed for Π_{it}^j, $j \in \{l, h\}$, $i \in \{1, 2\}$, $t \in \{s, m\}$.
  - The firm can always make money in either category.

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[1]Or $\delta - \frac{P}{Q}$ for category 2.

Timing

▶ The sequence of events is as follows:
  ▶ Nature selects the firm's quality according to the prior λ.
  ▶ 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 Λ on the quality.
  ▶ He decides whether to buy.
▶ We look for **pure-strategy** equilibria.
  ▶ We will only discuss **separating equilibria**.[2]

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[2]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

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

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

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

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

- 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.

- In a **pooling** equilibrium, let

$$\bar{\Pi}^t_{ma}(P_1, P_2) = \left(1 - \frac{P_1}{\bar{q}_1}\right)(P_1 - \alpha C_{1s}^t) + \left(\delta - \frac{P_2}{\bar{q}_2}\right)(P_2 - \alpha C_{2s}^t)$$

  be the type-t firm's profit under prices P_1 and P_2, $t \in \{l, h\}$.
  - $\bar{q}_i = \lambda q_i^h + (1 - \lambda)q_i^l$ is the expected quality of service i, $i \in \{1, 2\}$.

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

$$(P_{1ma}^{h^*}, P_{2ma}^{h^*}) = \operatorname*{argmax}_{P_1, P_2} \quad \Pi_{ma}^h(P_1, P_2)$$

$$\text{s.t.} \quad \bar{\Pi}_{ma}^l(P_1, P_2) \leq \Pi_{ma}^l(P_{1ma}^{l^*}, P_{2ma}^{l^*})$$

$$\bar{\Pi}_{ma}^h(P_{1ma}^{l^*}, P_{2ma}^{l^*}) \leq \Pi_{ma}^{h^*}.$$

and for the low-quality firm

$$(P_{1ma}^{l^*}, P_{2ma}^{l^*}) = \operatorname*{argmax}_{P_1, P_2} \quad \Pi_{ma}^l(P_1, P_2)$$

$$\text{s.t.} \quad \bar{\Pi}_{ma}^h(P_1, P_2) \leq \Pi_{ma}^h(P_{1ma}^{h^*}, P_{2ma}^{h^*})$$

$$\bar{\Pi}_{ma}^l(P_{1ma}^{h^*}, P_{2ma}^{h^*}) \leq \Pi_{ma}^{l^*}.$$

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 along 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

▶ Why upward prices distortions are required?
  ▶ 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 (when 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, there are prices.
  - Under incomplete information, the **prices may become higher**.
  - "My quality is high, otherwise I will not charge such a high price."
  - Information asymmetry causes **inefficiency**.
- It is still possible for the prices to 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.
- Let

$$\bar{\Pi}_s^l(P) = \left(1 - \frac{P}{\bar{q}_1}\right)(P - C_{1s}^l)$$

  be the type-l firm's profit under price P in a **pooling** equilibrium.
- Let $\Pi_s^{h^*}$ and $\Pi_m^{l^*}$ be the type-h and type-l firms' equilibrium profits under separation.

Signaling also through specialization

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

$$P_s^{h^*} = \operatorname*{argmax}_{P} \quad \Pi_s^h(P)$$
$$\text{s.t.} \quad \bar{\Pi}_s^l(P) \leq \Pi_m^{l^*}$$
$$\Pi_{ma}^{h^*} \leq \Pi_s^{h^*}.$$

  ▶ 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 along**.
  ▶ 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 include **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 though 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., δ is small).
   ▶ When price sensitivity is high (so large price distortions are harmful).
   ▶ When consumers are not confident about the quality (i.e., λ is small).