Lecture 9: Product Differentiation

Primary reference: McAfee, Competitive Solutions, Ch. 4
Entry in the Cournot Model

- Let $N$ be the number of firms and let them be symmetric.
- Let the fixed cost of entry be $F_E$.
  - If a firm does not enter, this cost is avoided.
- If demand is linear, with $y$-intercept $A$, slope $B$ and marginal cost $C$, equilibrium profit per-firm is
  $$\frac{(A - C)^2}{B(N + 1)^2} - F_E.$$
  - If this is negative, then the $N$th firm will not enter.
Entry in the Cournot Model

- If $F_E$ is very small, then a firm will be willing to enter even if there are a large number of firms. In this case, competition will be tough. With a large number of firms, each firm produces little output and earns little market share.

- If $F_E$ is very large, however, then only a small number of firms will find entry profitable.
  - It is possible for entry by a second firm to be strictly profitable,
    \[
    \frac{(A - C)^2}{9B} > F_E.
    \]
  - but entry by a third firm is not,
    \[
    \frac{(A - C)^2}{16B} < F_E.
    \]

- If competition is characterized by capacity buildup, and entry costs are high, an early mover should find the market appealing (all else equal).
Entry in the Cournot Model

- An even more appealing situation occurs where early movers pay smaller entry costs than followers.
  - Possession of a scarce resource that is harder for the 2nd firm to find.
  - Possession of very strong intellectual property rights that are very difficult to invent around.
- Let the fixed cost of the first entrant be $F_E$, and let the fixed cost of the second entrant be $F_{SE} > F_E$.
- Then the first mover can secure a monopoly if

\[
\frac{(A - C)^2}{4B} > F_E \quad \text{(Monopoly Profits are Big Enough for 1st Firm)}
\]

and

\[
\frac{(A - C)^2}{9B} < F_{SE} \quad \text{(Duopoly Profits Too Small for 2nd Firm)}
\]
Differentiated Products

- When products are **differentiated**, competition does not drive prices to marginal cost a la Bertrand.
- The choice of how to differentiate your product is key to reducing rivalry.
- For now, let’s just take differentiation is given and study how it affects competition.
- Two different important types of product differentiation, **horizontal** and **vertical** differentiation.
Horizontal Differentiation

- McAfee calls this differentiation by *variety*.
- Horizontally differentiated products have characteristics that are viewed differently by different customers.
  - Breakfast cereals differ according to sweetness.
  - Movies differ according to their target audience (five year olds prefer different movies from ten year olds).
  - Homogeneous products sold by firms in different locations differ according to geography.
- Fundamentally, two products are purely horizontally differentiated if, when both firms charge the same price, some consumers buy from one firm and some consumers buy from the other.
Let consumers differ according to their “location” on a line of length one.

In the simplest model, consumers are uniformly distributed on the line.

If firms L and R charge the same price, they split the market. The consumer right in the middle is indifferent between buying from L and R.
The Hotelling Line

- Cereals differ by their sweetness, consumers differ by their preference for sweet cereal.

- Homogeneous products differ by where they are sold, consumers differ by where they live.
Let a consumer’s location be $x$. Let his reservation value for either good be $V$.

If the consumer buys the product at the left end of the line, he “travels” distance $x$. If the consumer buys the product at the right end of the line, he “travels” distance $1 - x$.

Let this travel be costly. Suppose a consume who travels from one end of the line to the other suffers cost $c$, and consumers on the interior of the line suffer this cost proportional to distance traveled.

- The cost could be literally the opportunity cost of time times distance traveled.
- Alternatively, it could be disutility of not buying a preferred variety, e.g., the side effects of using a drug that is useful for a given condition but not ideal.

Traveling to the left end of the line entails travel cost $xc$, while traveling to the right end of the line entails travel cost $(1 - x)c$. 

Which Product to Buy

- Let the prices be $P_L$ and $P_R$.
- For a consumer located at $x$, the utility from buying at the left end of the line is
  \[ V - P_L - xc, \]
  while buying from the right end of the line brings utility
  \[ V - P_R - (1 - x)c. \]
- This consumer buys from the firm at the left end of the line if
  \[ V - P_L - xc > V - P_R - (1 - x)c. \]
Which Product to Buy

- The *pivotal* customer, who is indifferent between $L$ and $R$, satisfies
  \[ x^* = \frac{1}{2} + \frac{P_R - P_L}{2c}. \]
- With equal prices the market is split evenly.
- If $P_R > P_L$, the pivotal customer is to the right of $\frac{1}{2}$. Firm $L$ captures more demand.
- When $L$ lowers $P_L$, it increases its demand proportional to $\frac{1}{c}$.
  - When $c$ is very small, a price cut steals a lot of business.
  - When $c = 0$, we’re back in a Bertrand situation.
Profit Maximization

- Assuming (for simplicity) no marginal production costs, firm $L$ maximizes
  \[ P_L \left[ \frac{1}{2} + \frac{P_R - P_L}{2c} \right] \]
- Firm $L$’s best-response satisfies
  \[ P_L = \frac{1}{2}c + \frac{1}{2}P_R \]
- Firm $L$’s best response is to price halfway between the travel cost and the other firm’s price.
  - The more differentiated the products, the higher my price.
  - The higher the other firm’s price, the higher my price.
Best Response Functions

- Best-response functions are upward sloping.
- Prices are **strategic complements**—when the other firm raises its price, it is optimal for me to raise mine.
- Capacities are **strategic substitutes**, in contrast.
If both firms play best-responses, then the resulting Nash equilibrium satisfies $P_L = P_R = c$.

Firms price at the level of the travel cost and earn profit $\frac{c}{2}$ each.

The more differentiated the products, the more profitable the market.

If $c = 0$, firms price at marginal cost and you get the Bertrand outcome.
Endogenous Location

- Obviously, firms can choose product characteristics in ways that grab demand.
- In the Hotelling Line model, we think of this as picking the point to sell from. Firms need not choose the ends of the line.
- To start thinking about this problem, imagine that prices are fixed at $P_L = P_R = \bar{P}$.
- Firms then choose where to locate and consumers buy from the closest vendor.
- The classic motivation for this is ice cream vendors along a stretch of beach boardwalk.
- By moving one fifth of the total distance to the right, firm $L$ adds one tenth of market share.
- Obviously, firm $R$ will not sit still. So where does this all end?
Both firms move to the middle, capture half of the market each.

What non-business phenomenon does this look like?
Endogenous Location

- Now reintroduce price competition.
- If the firms are at the ends of the line, they each earn profit $\frac{C}{2}$. What do they earn if they are in the middle?
- It is Bertrand competition all over again. By undercutting the other firm, either firm captures all the demand.
- The equilibrium is marginal-cost pricing and zero profit.
It would appear that firms are better off by maximally differentiating unless prices are somehow fixed.

However, the incentive to “move to the middle” may remain...that is, there could be a type of prisoner’s dilemma where the firms are jointly better off maximally differentiated, but have dominant strategies to move.

There are two effects, a demand effect and a strategic effect, and either may dominate. What are these effects?

In practice, we observe both spatial differentiation (e.g. drycleaners) and spatial agglomeration (e.g. Home Depot and Lowe’s on Hwy 316).
Vertical Differentiation

- Mcafee calls this differentiation by *quality*
- Vertically differentiated products have characteristics such that all consumers would have ordinal preferences that are the same, neglecting price differences.
  - That is, if there are two goods where one is of higher quality, then if the prices are the same, *all* consumers prefer the higher-quality good.
- Cars include many quality characteristics, such as MPG, 0-60 acceleration, etc.
- High-definition TVs come in low-resolution (720p) and high-resolution (1080p).
A Model of Vertical Differentiation

Let consumers be distributed between 0 and 1 according to their “taste” for quality.

That is, consumer $x$’s utility from purchasing quality $s$ for price $P_s$ is

$$xs - P_s$$
A Model of Vertical Differentiation

- Let there be two firms (1 and 2) selling products of quality $s_1$ and $s_2$ and choosing prices $P_1$ and $P_2$. Let $s_1 > s_2$, so that firm 1 is the “high-quality” firm.

- Then consumer $x$ prefers the high-quality good if

$$xs_1 - P_1 > xs_2 - P_2.$$ 

The pivotal buyer is indifferent between the two goods:

$$x^* = \frac{P_1 - P_2}{s_1 - s_2}.$$
Market Shares

- Price competition leads to
  
  \[ P_1 = \frac{2(s_1 - s_2)}{3}, \quad P_2 = \frac{s_1 - s_2}{3} \]

- Consumers with a higher taste for quality buy the high-quality good.
Vertical Differentiation - Interpretation

- If qualities are the same, we get Bertrand competition and marginal-cost pricing again...no good.
- Firms have a cleaner incentive to maximally differentiate when differentiation is on the quality dimension. Prices and profits are both increasing in $s_1$ and $s_2$.
- If two firms play a two-stage game where they first choose qualities (which cost the same to produce), then compete in prices, what are the equilibria?
Horizontal and Vertical Differentiation

- In some instances, goods are differentiated along both the variety and quality dimensions.
- Many students prefer to attend college within driving distance of home. As a result, colleges and universities typically enroll more nearby students.
- Colleges and universities are also vertically differentiated by their teaching quality, research output, reputations, on-campus recruiting, etc.
- Top colleges and universities operate at full capacity.
- Interestingly, “selective” colleges and universities seem to have a lot of market power.
Switching Costs

- Products and services are often costly to switch.
  - Closing an account in one bank and opening an account in another requires paperwork.
  - Switching from one word processing program (e.g. WordPerfect) to another (e.g. MSWord) requires time spent learning.
  - Flying Delta when one’s accumulated frequent-flyer points are higher at United is less rewarding.

- What do switching costs do to firm behavior and to competition?
Think of a two-period game where firms sell products to consumers in both periods.

Consider first an extreme case where customers who buy from one firm are completely locked in in the second period.

Typically (in the model), firms engage in “bargain, then ripoff” pricing strategies—competition is brutal (perhaps below marginal cost) in the first period, then monopolistic in the second period.

In general, new consumers are entering the market all the time, so the firm trades off pricing low to capture such customers versus pricing high to earn high profits from locked-in customers.
Switching Costs

- Generally, profits are enhanced by switching costs. They “soften” competition.
- Moreover, when one firm moves first (American Airlines’ frequent-flyer program in the early 1980s), other firms prefer to imitate...and all firms benefit when the firms jointly serve more locked-in customers.