Introduction to Industrial Organization
Professor: Caixia Shen Fall 2014
Lecture Note 15

1. **Product differentiation (Ch. 12)-continue**
2. **Strategic pricing behavior 1: predation**

We have discussed Salop circle model last class. We have also discussed how to model product differentiation. We will review this part and discuss more on realistic models today.

How do we model horizontal and vertical differentiation? Below, let U_{i1} and U_{i2} denote individual I's utility from goods 1 and 2. Let $\delta_1 and\ \delta_2$ denote the quality level of goods 1 and 2. Let p_1 and p_2 denote prices.

1) Horizontal differentiation ($\delta_1 = \delta_2 = \delta$)

$$U_{i1} = \delta - p_1 + \varepsilon_{i1}$$
$$U_{i2} = \delta - p_2 + \varepsilon_{i2}$$

ε_{i1} and ε_{i2} are idiosyncratic shocks to 's utility for 1 and 2. They are the source of the horizontal differentiation.

Purchase 1 if $U_{i1} > U_{i2}$ ⇔ $\delta - p_1 + \varepsilon_{i1} > \delta - p_2 + \varepsilon_{i2}$
⇔ $p_2 - p_1 > \varepsilon_{i2} - \varepsilon_{i1}$

If $p_1 = p_2$, buy good 1 if $\varepsilon_{i1} > \varepsilon_{i2}$.
If $p_1 = p_2$, buy good 2 if $\varepsilon_{i1} < \varepsilon_{i2}$.

$\varepsilon_{i1}\ and\ \varepsilon_{i2}$ represent idiosyncratic shocks to I's utility. If goods 1 and 2 are

- Restaurants: $\varepsilon_{i1}\ and\ \varepsilon_{i2}$ might = -1 × distance from I's home to the restaurants
- Credit cards: $\varepsilon_{i1} and\ \varepsilon_{i2}$ might equal utility from cash back and divided miles.
- Windows vs Mac: $\varepsilon_{i1} and\ \varepsilon_{i2}$ might equal importance individual i places on business application and style.

Main point: even if $\delta_1 = \delta_2$ and $p_1 = p_2$, some consumers will strictly prefer good 1, other will strictly prefer 2.

2) Vertical differentiation
   - Assume that product 1 higher quality than 2 ($\delta_1 > \delta_2$)
   - But consumer vary in how much they value quality

     Let $U = \theta\delta - p$ so that $\frac{dU}{d\delta} = \theta$. Consumer i willing to pay θ_i dollarsfor extra unit of quality.
   - Thus,

$$U_{i1} = \theta_i\delta_1 - p_1$$
$$U_{i2} = \theta_i\delta_2 - p_2$$

If $p_1 = p_2$, then everyone will purchase good 1 since $\delta_1 > \delta_2$.

$$U_{i1} > U_{i2} \iff \theta_i \delta_1 - p_1 > \theta_i \delta_2 - p_2$$
$$\iff \delta_1 > \delta_2$$

If $p_1 > p_2$, then I will purchase good 1 if he cares a lot about quality

$$U_{i1} > U_{i2} \iff \theta_i \delta_1 - p_1 > \theta_i \delta_2 - p_2$$
$$\iff \theta_i \delta_1 - \theta_i \delta_2 > p_1 - p_2$$
$$\iff \theta_i > \frac{p_1 - p_2}{\delta_1 - \delta_2}$$

Usually we think that income is an important determinant of θ. High income people are willing to pay more for quality than low income people. But the determinants of θ depends upon that differentiates the products. For example if good 1=fast computer and good 1=slow computer, than $\theta_i = i^{'}$s need for computing power. Or if 2=less generous health insurance and 1=generous health insurance, $\theta_i = i'$s health.

3) In practice, goods are horizontally and vertically differentiated. Hybrid models can also be used.
    - For example, a Toyota convertible is horizontally and vertically differentiated from a Mercedes minivan. As single men prefer convertibles to minivans. Large families prefer minivans to convertibles. Notice that Mercedes higher quality than Toyota.
    - Let $U_{ij} = utility\ individual$ i$gets\ from\ product$ j

$$U_{ij} = \delta_j - \theta_i p_j + \varepsilon_{ij}$$

- δ_j: $j^{'}svertical\ quality$
- θ_i: $i's\ willingness\ to\ pay\ for\ quality$
- ε_{ij}: $``i"\ 's\ indiosyncratic\ tastes\ for\ j.$

- Suppose we wanted to apply this type of model to the automobile market. We can let preferences depend on a combination of individual "i" 's and product "j" 's characteristics.

  For example:

$$U_{ij} = \delta_j - \theta_i p_j + \varepsilon_{ij}$$

- $\delta_j = \alpha_1 Horsepwoer + \alpha_2 Leather + \alpha_3 Luxury\ Brand$

  All consumers would prefer to buy a car with more horsepower, leather seats, that is produced by Mercedes or BMW if it was not more costly. We expect $\alpha_1 > 0$, $\alpha_2 > 0$, $\alpha_3 > 0$.

- $\theta_i = \beta_1 Income_i + \beta_0$

  "i" 's willingness to pay for quality (or his price sensitivity)

- We should expect $\beta_0 > 0$, so that prices make all consumer worse off. But $\beta_1 < 0$, so that consumers who make more money are less price sensitive than poorer consumers.

- For example, if $\beta_0 = 10$ $and\ \beta_1 = -0.05$, then a $1 increase in price p of product j causes utility to go down $\theta_i = 5$ units if $Income_i = \$100K$ and $\theta_i = 7.5$ units if $Income_i = \$50K$.
- Finally, we can let ε_{ij} be a function of family and car characteristics.

  $\varepsilon_{ij} = (\gamma_1 Family\ Size_i)Minivan_j + (\rho_1 Family\ Size_i)Convertible_j + \omega_{ij}$

  As family size increases, utility from minivans increases if $\gamma_1 > 0$.

  As family size increases, utility from convertibles decreases if $\rho_1 < 0$.

  So in equilibrium, if γ_1>0 and $\rho_1 < 0$, large families will purchase minivans and small families will purchase convertibles.

- Finally, ω_{ij} is an error term. We include it because we realize that we can write down a model that perfectly captures preferences over automobiles.
- In a logit model, we assume ω_{ij} is logistically distributed. So that ω_{ij} comes from a distribution that looks similar to a normal distribution.

If ω_{ij} is logistically distributed then,

$$probability\ that\ i\ purchases\ j = \frac{e^{U_{ij}}}{1 + \sum_{j'} U_{ij'}}$$

Suppose there are M_n^i families in the country of size n with income i. Let M_{nj}^i be the number of families of size n who purchase car j. Let M_{n0}^i be the number of families of size n who purchase no car. Can use algebra to show that

$$\log\left(\frac{M_{nj}^i}{M_n^i}\right) - \log\left(\frac{M_{n0}^i}{M_n^i}\right) = U_{ij} + \omega_{ij}$$

$$= \alpha_1 Horsepwoer + \alpha_2 Leather + \alpha_3 Luxury\ Brand - (\beta_1 Income_i + \beta_0)price_j + (\gamma_1 M)Minivan_j + (\rho_1 M)Convertible_j + \omega_{ij}$$

This equation relates market share of different cars within different consumer groups to car and consumer characteristic. We can easily get market share data and consumer data to estimate $\alpha, \beta\ and\ \gamma$.

In a famous paper, Amil Petrin used market share data for automobiles to estimate demand for cars in the 1980's and 1990's after minivans were introduced in 1984. As expected $\gamma_1 > 0$. Large families benefited a lot from the existence of minivans.

Using the estimated model, he simulates the increase in consumer surplus from minivans:

1) He removes minivans from the choice set (large families hurt by this)
2) He uses a Bertrand model to simulate effect of (1) on prices (all families mode worse off).
3) He recalculates CS: decreases by $312 per family year. 40% decrease due to increase in prices.

Strategic pricing behavior 1: predation

Predatory pricing

A firm lowers its price in order to drive rivals out of business and scare off potential entrants. Then the firm increases prices when there is no longer a threat of entry.

- Will see that predatory pricing implies short term losses but long term gains.
- Basic example:
  Two firms (firm 1 is predator) have identical cost functions and produce the same product. Therefore if firm 1 chooses a very low price p1, then firm 2 must match it or sell nothing.

  Below, firm 1 charges a very low price and is committed to satisfying demand at this low price.

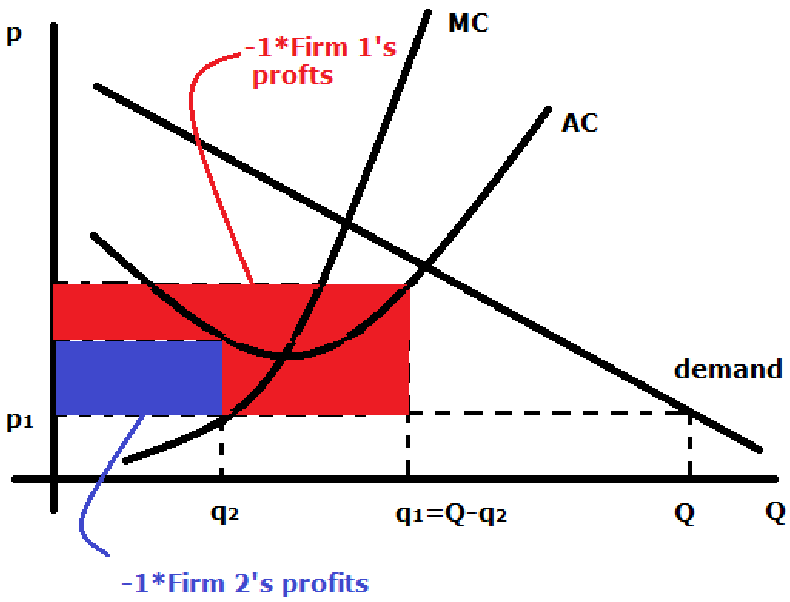

Figure 1: Firm 1's predatory pricing

In the figure, firm 1 charges an extremely low price p1. If firm 2 matches this price it will sell q_2 units of output. This is profit maximizing. For firm 2 since $MC(q_2)=p_1$, but firm 2 still makes negative profits since $p_1<AC(q_2)$.

But note that firm 1's profits are even more negative than firm2's. Firm 1's profits reflect the fact that firm 1 is forced to satisfy all of demand at p_1. If firm 1 was not willing to produce $Q-q_2$ units of output, then there would be excess demand and firm 2 would be close to raise it's price.

Why does firm 1 do this? Because if firm 2 is force form the market firm 1 can hen charge monopoly prices. Monopoly profits always exceed duopoly profits.

But how does this predatory pricing work? If firm 1 can drive firm 2 out of the market, why can't firm 2 do the same thing to firm 1? Or, why doesn't firm 2 just ride out the storm since it knows that it is earning profits greater than firm 1's? Firm 2 knows that firm 1 can't price at p1 forever, so firm 2 can just temporarily exit the market.

We can state the previous logic more rigorously. Consider for profit levels.

$$\pi^M = monopoly\ profits\ if\ 1\ a\ monopolist$$
$$\pi^D = duopoly\ profits\ if\ 1\ and\ 2\ compete\ normally$$
$$\pi_1^p = 1's\ profits\ if\ they\ engage\ in\ predatory\ pricing$$
$$\pi_2^p = 2'sprofits\ if\ 1\ engages\ in\ predatory\ pricing$$

Note that $\pi^M > \pi^D > 0 > \pi_2^p > \pi_1^p$.

Suppose there are two periods and firms 1 and 2 play the following game:

1) Firm 2 enters
2) Firm 1 decides to charge a duopoly price p^D or predatory price (p_1 on previous slide)
3) Firm 2 exits or stays in the market
4) Move on to period 2

Game can be drawn in extensive form:

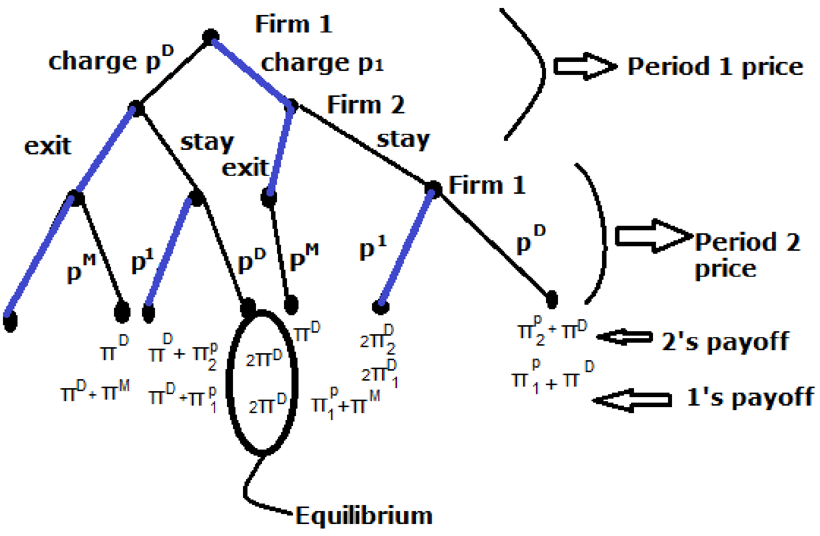

Figure 2: Extensive-form game

We can look at every possible period "state of the world" and ask what firm 1's optimal price is. I cross out those prices that are not optimal. Firm 2 knows that in period 2, firm 1 will never find it optimal to engage in predatory pricing.

Taking the above statement into account, firm 2 knows that regardless of what price firm 1 set in period 1, firm 1 will charge p^D in period 2 if 2 does not exit. So, taking this into account, firm 2 will never exit.

Taking the statement above into account, firm 1 can charge p^D in period 1 and earn $2\pi^D$ or it can charge p' in period 1 and earn $\pi_1^p + \pi^D$. Since $\pi_1^p + \pi^D < 2\pi^D$, firm 1 will rationally charge p^D in period 1.

Thus, if firms 1 and 2 are identical and there is no uncertainty we should not ever see predatory pricing occur. We can generate predatory pricing by firm 1 by relaxing either of these two assumptions:

1) Story 1: We can give firm 1 an advantage over firm 2. For example, we can allow firm 1 an advantage in financing. Predatory pricing can be rational by firm 1 if it forces firm 2 into bankruptcy.
2) Story 2: We can make firm 2 believe that firm 1 will continue charge p' by adding uncertainty to the model. Firm 2 may be unsure if firm 1 is charging p' because of predatory pricing, or because firm 1 has very low costs.

Story 1:

- Suppose firm 1 has existed for a long time and has large cash reserves.
- Firm 2 is a new entrant into the market and has very little cash
- If firm 1 charges p' in period 1, 2 earns $\pi_2^p < 0.$ since firm 2 has no extra cash it forces bankruptcy unless it receives a loan from a bank. If it is unable to secure a loan it must exit the market ever if it knows that firm 1 will not use predatory pricing in period 2.
- Let $\gamma = firm\ 1'sbelief\ about\ the\ probability\ that\ firm\ 2\ will\ get\ a\ loan.$ Implies firm 1 will charge p' if $\pi^D + \pi^D < \pi_1^p + \gamma\pi^D + (1-\gamma)\pi^M$
$$\rightarrow \pi^D - \pi_1^p < (1-\gamma)(\pi^M - \pi^D)$$

Where $\pi^D - \pi_1^p$ is the cost of predation; $(1-\gamma)(\pi^M - \pi^D)$ is the expected benefit of predation, which increases as γ decreases.

Story 2:

Let demand be given by $p = a - bq$

We know that $p^M = \frac{a+c}{2}$

If firm 1 and 2 have marginal costs c_1 and c_2. We know that the Cournot duopoly price is equal to $p^D = \frac{a+c_1+c_2}{3}$.

Suppose firm 2 is uncertain about demand (a) and firm 1's cost c_1.

If firm 1 charges p', firm 2 will believe there is a probability $(1-\gamma)$ that firm 1 has very low costs and is not behaving in a predatory fashion (i.e., firm 2 mistakenly believes the duopoly price is p'). If firm 2 believes this, it will think that entering the market was a mistake.

Again, firm 1 will engage in predatory pricing if $\pi^D - \pi_1^D < (1-\gamma)(\pi^M - \pi^D)$. As firm 2 becomes increasingly convinced firm 1 has low costs, predation becomes more likely.

According to these stories:

1) We will observe predation in the real world.
2) Predation will be rational for firm 1.
3) Predation will be successfully force firm 2 to exit $1-\gamma$ percent of the time.

Predation and Law

Predatory pricing is illegal under the Sherman Act

Sherman Act prohibits any behavior deemed to be an attempt at monopolization. Predatory pricing is intended to create monopolies.

Proving predatory pricing very difficult though. Every one of our competitive models predicts that when entry occurs, incumbents lower their prices.

Many economists suggest using marginal cost or average variable cost thresholds. In out model a rational firm would never set $price < marginal\ cost$ or $price < AVC$, unless it is engaging in predatory pricing.

But:

1) It is very difficult to determine the shape of MC and AVC
2) Although our models say that no firm could set price under MC, other models do.

- Short run promotional activities aimed at attracting customers entrails price=0.
- In "learning by doing" models, firms' costs decrease the more it produces because it learns from its mistakes. A firm might charge a low price to sell high Q, thereby giving it the opportunity to "learn". When there is competitor have to charge an extremely low price to sell enough q to learn.

Example of predatory pricing case: DOJ vs American Airlines 2001

Case was about AA's pricing behavior for flights out of Dallas/Ft worth airport.

- Several small airlines (Vanguard, Western Pacific, SunJet) entered market in 1990's.
- Between 1995 and 1997, these small airlines charged much lower fares than AA's historical prices. Consumers benefitted, air travel increased a lot.
- American airlines responded in two steps:
  1) Initially, AA matched the low-cost carriers (LCCs) on a limited basis: matching prices in some markets but not others.
  2) Then (according to the DOJ) AA become concerned that the LCCs could form a permanent hub out of Dallas. So AA then shifted to a more aggressive response:
     - ✓ Increased availability of low fares on more flights
     - ✓ Added flights

- ✓ Used larger aircrafts
- ✓ Entered new routes. Specifically AA started offering Dallas-Long beach flights, a route it had exited because of lack of profits until SunJet started offering flights.

- ➢ Eventually the low cost carriers ceased operations. Unable to establish permanent presence in Dallas. Either went out of business or moved operations elsewhere.
- ➢ After this exit occurred, AA raised prices and reduced the number of fights it offered, basically back to their original level.

DOJ's strategy?

- ➢ Tried to argue that AA's response was a competitive one. But AA realized LCCs might form a permanent presence.
- ➢ So second response intended as predatory pricing to drive LCCs out of market.
- ➢ Using various cost measures, argued that if AA had continued response 1, instead of shifting to response 2, they would have earned an extra $41 million.

Despite this evidence, judge threw out DOJ's case. AA was able to justify its behavior as short-run profit maximizing:
Consider the following hub and spoke model:

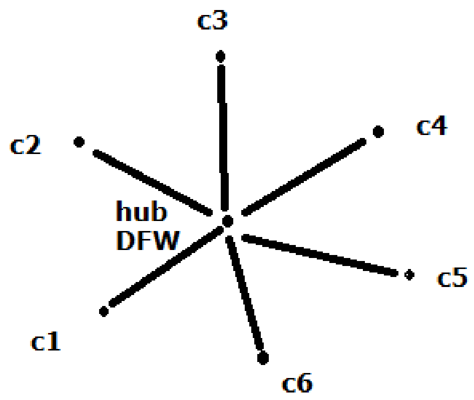

Figure 3: Hub-and-spoke system

DFW is the hub connected to 5 cities. Total number of cities, n=6, total number of flights=n(n-1) of which 2(n-1) are direct.

- ➢ Assume AA is a monopolist on all n(n-1) flights until a low-cost carrier enter (hub, city 1) market. Low cost carrier has lower marginal costs than AA. See in Figure 4.
- ➢ AA has two options:
  1) Compete in (hub, c1) and charge price<MC
  2) Concede the market and only offer hub-c2-c1 flights

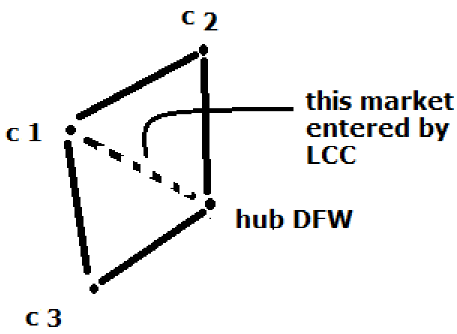

Figure 4: Hub-and-spoke system

Can tell a price discrimination story such that loss under response 1 smaller than loss under response 2:

- If AA concedes (c1, hub) it will serve (hub-c1) customers (who are on their way to c1 via c2) and (hub-c2) customers on (hub-c2) flights
- The (hub-c1) customers have low WTP but discrimination not possible.
- So AA has to lower its price on (hub-c2) flights, losing money on the high WTP (hub-c2) customers.
- AA does better offering (hub-c1) flights and losing money because it allows them to continue charging high prices on (hub-c2) flights.