ECON-UN 3211 - Intermediate Microeconomics

Recitation 9: Imperfect competition

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Review of relevant concepts: profit maximization and market structure

Perfect competition vs. monopolistic competition

Oligopolies: theories of imperfect competition

Some additional takeaways

Review of relevant concepts: profit maximization and market structure

The Producer's Problem I: Cost Minimization (Recitation 5)

$$\max_q \pi(q) = \max_q \{TR(q) - TC(q)\}$$

Step 1: Cost minimization

$$\min_{\{x_1,x_2\}} w_1x_1 + w_2x_2$$

$$\text{s.t. } f(x_1, x_2) \geq q$$

Given:

- technological constraint $f(x_1, x_2)$
- input prices w_1, w_2
- output quantity q

Derive:

- conditional factor demand functions

$$x_1^*(w_1, w_2, q)$$

$$x_2^*(w_1, w_2, q)$$

- cost function

$$TC(q) = w_1x_1^*(w_1, w_2, q) + w_2x_2^*(w_1, w_2, q)$$

The Producer's Problem II: Supply Choice (Recitation 6)

$$\max_q \pi(q) = \max_q \{TR(q) - TC(q)\}$$

Step 2: The supply decision

$$\max_q p(q)q - c(q)$$

$$\text{s.t.} \quad q \geq 0$$

Given

- Consumer demand function $q^D(p)$
- Producers' cost function $c(q)$

Derive:

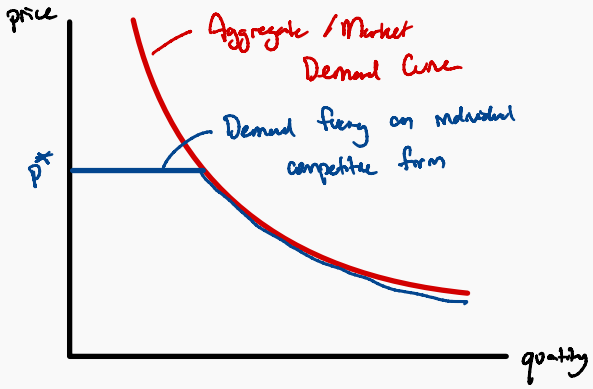
- Marginal revenue $MR(q)$
- Marginal cost $MC(q)$

Optimization:

- First-order condition sets $MR(q) = MC(q)$
- This gives profit-maximizing supply choice q^*

Market structure and the demand facing the firm

- The structure of the market a firm is in determines the demand it faces
- A monopolistic firm is the only producer in the market and responds to the aggregate demand curve
- A purely competitive firm is a “price taker” meaning they respond to the flat demand curve with a constant market price
- Recitation 6: just choose the most profitable quantity q^* to supply at this fixed price p^*



Market structure and marginal revenue $MR(q)$

Total revenue:

$$TR(q) = p(q)q$$

Marginal revenue:

$$\begin{aligned} MR(q) &= \frac{dTR(q)}{dq} \\ &= \frac{dp(q)q}{dq} \\ &= \frac{dp(q)}{dq}q + p(q)\frac{dq}{dq} \\ &= p(q) + p'(q)q \end{aligned}$$

- $p(q)$ is the quantity effect: the increase in revenue from selling an additional unit of output, which is also the price at quantity q
- $p'(q)q$ is the price effect: the decrease in revenue associated with having to lower the price on all previous units in order to be able to sell the qth unit

Market structure and the firm's profit-maximizing first-order condition

Thus, the general first-order condition:

$$\begin{aligned} MC(q) &= MR(q) \\ &= p(q) + p'(q)q \end{aligned}$$

$= p^* + 0 \cdot q = p^*$

Can think of this as the relevant demand curve (a quantity effect) plus a price effect that depends on the slope $p'(q)$ of the demand curve

$p(q) = p^*$

$\Rightarrow p'(q) = \frac{d}{dq} p^*$

$= 0$

1. Under perfect competition,
   1. Price-taking means the quantity effect is constant p^*
   2. And the firm exerts no price effect (the definition of a price taker)

The first-order condition simplifies to

$$MC(q) = p(q)$$

$= p^*$

This means at the optimal supply choice, the competitive firm charges exactly their cost of production (no markup)

Market structure and the firm's profit-maximizing first-order condition

Thus, the general first-order condition:

$$\begin{aligned} MC(q) &= MR(q) \\ &= p(q) + p'(q)q \end{aligned}$$

Can think of this as the relevant demand curve (a quantity effect) plus a price effect that depends on the slope $p'(q)$ of the demand curve

$p(q)$ is a decreasing function

$\Rightarrow p'(q) < 0$

for a monopolistic firm, it's the market/aggregate demand function

2. Under imperfect competition,

$$\begin{aligned} MC(q) &= p(q) + p'(q)q \\ &\leq p(q) \end{aligned}$$

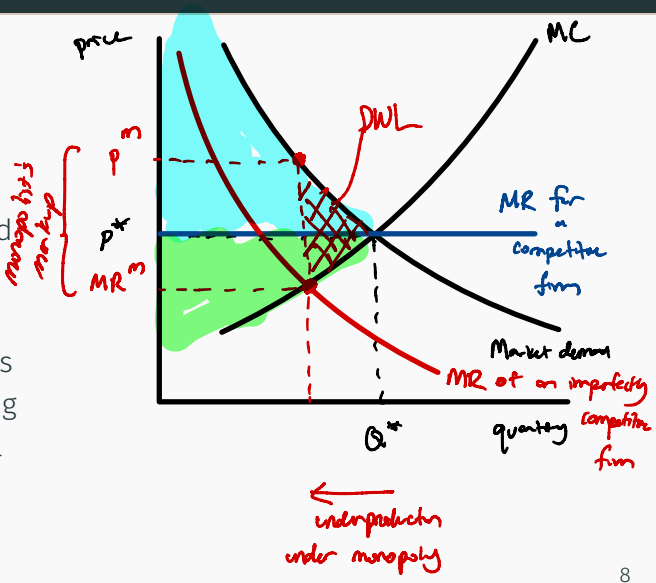
MR of an imperfectly competitive firm is less than AR

- In general, uncompetitive market power allows firm to exert both quantity *and* price effects
- At the optimal supply choice, the firm may charge a market price greater than their marginal cost

Market structure and the firm's profit-maximizing first-order condition

$$\begin{aligned} MC(q) &= MR(q) \\ &= p'(q)q + p(q) \end{aligned}$$

- Under pure competition, MR is the same as the flat demand curve and optimal supply is where it crosses marginal cost
- Under imperfect competition, MR is smaller than the downward-sloping market demand curve and optimal supply is lower and the firm can charge a price higher than their production cost!



Perfect competition vs. monopolistic competition

Practice problem 1: Monopolistic competition with identical consumers

a) What is a monopolist's optimal two-part tariff (i.e., unit price and entry fee)?

inverse demand curve

$\Rightarrow \frac{p}{2} = 20 - q$

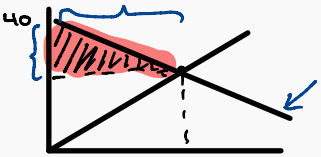
$\Rightarrow p^D(q) = 40 - 2q$

- Consumer demand

$$q^D(p) = 20 - \frac{p}{2}$$

- Production cost

$$c(q) = 10q$$



1. per-unit price

$MC(q) = p^D(q)$

$\Rightarrow 10 = 40 - 2q$

$\Rightarrow q^* = \frac{30}{2} = 15$

$\Rightarrow p^* = p^D(q^*) = 40 - 2(15) = 10$

2. entry fee : captures the entire consumer surplus

$CS = \frac{(40 - p^*) \times q^*}{2} = (40 - 10) \times 15/2 = 450/2 = 225$

Optimal two-part tariff : per-unit price of \$10
entry fee of \$225

Practice problem 1: Monopolistic competition with identical consumers

b) What is the resulting consumer and producer surplus? Deadweight loss?

$CS = 0$

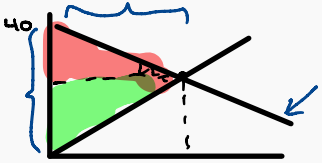
$PS = \frac{1}{2}(40)(15) = 300$

- Consumer demand

$$q^D(p) = 20 - \frac{p}{2}$$

- Production cost

$$c(q) = 10q$$



- No DWL but now total surplus of 300 goes to the producer
- CS decreases from 225 to 0
- PS increases from 75 to 300

Practice problem 1: Monopolistic competition with identical consumers
Discussion

- So as we'd expect, we see that a lack of competition favors the producers at the cost of consumers
- In fact, because the consumers have the exact same willingnesses to pay, the freedom to set prices allows the monopolist to extract all consumer surplus so precisely that the transfer of surplus from consumer to producer has no deadweight loss
- For more on two-part tariffs, see Chapter 26 of Varian

Now we consider the more general case where consumers have different demands...

Practice problem 2: Monopolistic competition with heterogeneous consumers

a) What is the optimal price and quantity for this monopolist?

$TR(q) = p(q) \cdot q$

$MR(q)$

- Consumer demand

$$q_H^D(p) = 800 - p \quad = 0 \text{ when } p = 800$$

$$q_L^D(p) = 200 - \frac{p}{2} \quad = 0 \text{ when } p = 400$$

- Production cost

$$c(q) = 200q$$

Aggregate demand $Q^D(p) = \begin{cases} 1000 - \frac{3p}{2} & \text{if } 0 < p \leq 400 \\ 800 - p & \text{if } 400 < p \leq 800 \\ 0 & \text{otherwise} \end{cases}$

$\frac{3p}{2} = 1000 - Q$

$\Rightarrow p = \frac{2000}{3} - \frac{2Q}{3}$

$p = 800 - Q$

Convert to aggregate inverse demand $p^D(Q)$:

$$p^D(Q) = \begin{cases} \frac{2000}{3} - \frac{2Q}{3} & \text{if } 400 < Q \leq 1000 \\ 800 - Q & \text{if } 0 < Q \leq 400 \\ 0 & \text{otherwise} \end{cases}$$

Then $MR(Q) = \frac{d}{dQ}\left[p^D(Q) \cdot Q\right]$

$$MR(Q) = \begin{cases} \frac{2000}{3} - \frac{4Q}{3} & \text{if } 400 < Q \leq 1000 \\ 800 - 2Q & \text{if } 0 < Q \leq 400 \\ 0 & \text{otherwise} \end{cases}$$

Practice problem 2: Monopolistic competition with heterogeneous consumers

a) What is the optimal price and quantity for this monopolist?

- Consumer demand

$$q_H^D(p) = 800 - p$$

$$q_L^D(p) = 200 - \frac{p}{2}$$

- Production cost

$$c(q) = 200q$$

Monopolist chooses Q s.t. $MR(Q) = MC(Q)$

$= 200$

First suppose both consumers participate:

$$\frac{2000}{3} - \frac{4Q}{3} = 200 \Rightarrow Q^* = \frac{2000 - 600}{4}$$

$= 350$

This is outside the range of quantities consistent with both consumers participating ($400 < Q \leq 1000$)

Then if only high types participate:

$$800 - 2Q^* = 200 \Rightarrow Q_H^* = \frac{600}{2} = 300, \quad P_H^* = 800 - Q^*$$

$= 500$

This is consistent with the corresponding range of quantities ($0 < Q \leq 400$) so is a valid equilibrium

Practice problem 2: Monopolistic competition with heterogeneous consumers Discussion

Recall our decomposition of marginal revenues:

1. A quantity effect: some are more willing to pay a given price for the product
2. A price effect: Even if they have the same demand at a given price, some might be more sensitive to changes in the price, i.e., have a different demand elasticity as captured by the slope of their demand function

What does this mean for our monopolist?

- In practice problem 1, the monopolist needed a specific price structure to extract all consumer surplus
- Here, the introduction of diversity of consumer preferences meant no single price structure allowed the monopolist to extract all consumer surplus from both types of consumers
- The monopolist has an incentive to charge different prices to the

Price discrimination

1. First-degree: charge every consumer the most they are willing to pay
   - Essentially, this is like solving practice problem 1 separately for each consumer
   - Able to extract all consumer surplus from everybody by charging them the highest price they're willing to pay

2. Second-degree: charge lower prices to consumers who buy higher quantities
   - Less precise targeting, but incentivizes consumers to self-differentiate themselves according to their specific preferences
   - More price-elastic consumers will tend to purchase higher quantities to access lower prices
   - Not covered in this course, but does also lead to greater producer surplus capture

Price discrimination

3. Third-degree: charge different prices according to different groups of consumers

- Think of the high and low types in the last practice problem. By charging only one price, the monopolist only captured one type of consumer and failed to capture any consumer surplus from the other.
- Third-degree price discrimination allows the producer to improve on this (from their self-interested perspective) by offering more favorable prices to the low types without making them available to the high types (who would improve their consumer surplus with the low-type prices)

Practice problem 2: Monopolistic competition with heterogeneous consumers

b) Calculate the optimal prices under third-degree price discrimination

We already calculated $p_H^* = 500$

- Consumer demand

$$q_H^D(p) = 800 - p$$

$$q_L^D(p) = 200 - \frac{p}{2}$$

For low types,

$$P_L(Q) = 400 - 2Q$$

$$\Rightarrow TR_L(Q) = P_L(Q) \cdot Q = 400Q - 2Q^2 \Rightarrow MR_L(Q) = 400 - 4Q$$

- Production cost

$$c(q) = 200q$$

$\Rightarrow$ optimal pricing is given by

$$400 - 4Q_L^* = 200 \Rightarrow Q_L^* = \frac{200}{4} = 50$$

$$\Rightarrow p_L^* = 400 - 2(50) = 300$$

optimal prices: $(p_L^* = 300, p_H^* = 500)$

Practice problem 2: Monopolistic competition with heterogeneous consumers

c) Compare the monopolists' profits with and without price discrimination

$$\Delta\pi = \pi_{DISC} - \pi_{NO\,DISC}$$

$$= \pi_L + \pi_H - \pi_H$$

$$= \pi_L$$

$$= (p_L^* - 200) \cdot q_L^*$$

$$= (300 - 200) \cdot 50$$

$$= 5000$$

- Consumer demand

$$q_H^D(p) = 800 - p$$

$$q_L^D(p) = 200 - \frac{p}{2}$$

- Production cost

$$c(q) = 200q$$

Oligopolies: theories of imperfect competition

Imperfect competition

- We've covered two extremes of market structure: pure competition and non-competition. We now turn to the intermediate case of imperfect competition
- This requires us to interrogate "price taking" a bit more: if market demand is downward-sloping, why would the price facing individual firms be fixed? And what determines that price p^*?
- First, let's look at an example with non-identical duopolists with price-setting ability and look at their incentives

Practice problem 3: Competition among duopolists

a) What price would each duopolist set if the other duopolist didn't exist

$P^D(Q) = 2400 - Q$

$TR(q) = p(Q) \cdot Q$

$= (2400 - Q) \cdot Q$

$MR(q) = 2400 - 2Q$

- Market demand

$$Q^D(p) = 2400 - p$$

- Production costs

$$c_1(Q) = 20Q$$

$$c_2(Q) = 10Q$$

Firm 1's monopoly pricing:

$2400 - 2Q = 20 \Rightarrow Q_1^* = \frac{2400 - 20}{2} = 1190$

$\Rightarrow p_1^* = 2400 - 1190$

$= 1210$

Firm 2's monopoly pricing:

$2400 - 2Q = 10 \Rightarrow Q_2^* = \frac{2400 - 10}{2} = 1195$

$\Rightarrow p_2^* = 2400 - 1195 = 1205$

A quick aside: Find the unique Nash Equilbrium of this game

$BR_1(L) = L$ $BR_2(L) = C$

$BR_1(C) = R$ $BR_2(C) = R$

$BR_1(R) = C$ $BR_2(R) = R$

Nash equilibrium occurs

$BR_1(R) = C$

$BR_2(C) = R$

Practice problem 3: Competition among duopolists

b) Borrowing this Nash Equilibrium concept, what is the outcome of Bertrand competition

- Market demand

$$Q^D(p) = 2400 - p$$

- Production costs

$$c_1(Q) = 20Q$$

$$c_2(Q) = 10Q$$

• Suppose firm 1 (who has higher MC = 20) is a monopolist
From part a, firm 1 sets $p = 1210$

• Now assume firm 2 enters the market

For illustration only, suppose prices must be whole numbers

Firm 2's best response to firm 1 setting price of 1210

$\Rightarrow BR_2$ (Firm 1 setting $p_1 = 1210$) $= 1209$

$\Rightarrow BR_1(1209) = 1208 \rightarrow BR_2(1208) = 1207 \ldots$ etc.

$\vdots$

$BR_2(21) = 20$

$BR_1(20) = 20$

$BR_2(20) = 19$

$BR_1(19) = 20$

Firm 1 cannot set price below MC,

$\therefore (20, 19)$ is a Nash Eq^m

With continuous prices, $BR_2(20) = 20 - \varepsilon$ for smallest possible $\varepsilon > 0$ and $BR_1(20 - \varepsilon) = 20$

$\Rightarrow NE: (20 - \varepsilon, 20)$

Practice problem 3: Competition among duopolists

c) How does the total surplus of this outcome compare to the case where firm 2 is a monopolist?

- Market demand

$$Q^D(p) = 2400 - p$$

- Production costs

$$c_1(Q) = 20Q$$
$$c_2(Q) = 10Q$$

Firm 2's monopoly price:

$2400 - 2q = 10 \Rightarrow q_2^* = \frac{2400 - 10}{2} = 1195$

$\Rightarrow p_2^* = 2400 - 1195 = 1205$

$CS = \frac{1}{2}(2400 - 1205)(1195)$

$\frac{1}{2}$ $Q^D(p_2^*)$ p^*

$= 714,012.5$

$PS = \frac{1}{2}(1205 - 10)(1195)$

$\frac{1}{2}(p^* - MC_1)(q^*)$

$= 714,012.5$

Total surplus w/ monopoly:

$CS + PS \approx 1,428,000$

Practice problem 3: Competition among duopolists

c) How does the total surplus of this outcome compare to the case where firm 2 is a monopolist?

- Market demand

$$Q^D(p) = 2400 - p$$

- Production costs

$$c_1(Q) = 20Q$$
$$c_2(Q) = 10Q$$

Under Bertrand competition

$p^*_{BERT} = 20$ $\quad Q^D(p^*_{BERT}) = 2400 - 20 = 2380$

$\Rightarrow CS = \frac{1}{2}(2400 - 20) \cdot 2380$

$Q^D(p^*_{BERT})$

$= 2,832,200$

$\Delta CS = 2,832,200 - 714,012.5$

$\approx +2,100,000$

$PS_2 = (20 - 10) \cdot 2380 = 23,800$

$(p^*_{BERT} - MC_2)\ q^*_{BERT}$

$= 23,800$

$\Delta PS = 23,800 - 714,012.5$

$\approx -700,000$

$CS + PS_2 = 2,856,000$

Δ Total Surplus $\approx +1,400,000$

Practice problem 3: Competition among duopolists

d) What is the outcome of Cournot quantity competition?

- Market demand

$$Q^D(p) = 2400 - p$$

$$p^D(Q) = 2400 - Q$$

- Production costs

$$c_1(Q) = 20Q$$

$$c_2(Q) = 10Q$$

$Q^D = q_1 + q_2 \Rightarrow q_1 = Q^D(p) - q_2$

$q_2 = Q^D(p) - q_1$

$\pi_1 = p(Q) \cdot q_1 - 20 \cdot q_1$

$= [2400 - Q] \cdot q_1 - 20 \cdot q_1$

$= [2400 - q_1 - q_2] \cdot q_1 - 20 \cdot q_1$

$= 2400 q_1 - q_1^2 - q_2 q_1 - 20 q_1$

FOC$_1$ $\Rightarrow 2400 - 2q_1 - q_2 - 20 = 0$

$\Rightarrow q_1^* = \frac{2380 - q_2^*}{2}$

By symmetry, FOC$_2$ $\Rightarrow 2400 - 2q_2 - q_1 - 10 = 0$

$\Rightarrow q_2^* = \frac{2390 - q_1^*}{2}$

} simultaneous equations

Practice problem 3: Competition among duopolists

d) What is the outcome of Cournot quantity competition?

- Market demand

$$Q^D(p) = 2400 - p$$

- Production costs

$$c_1(Q) = 20Q$$
$$c_2(Q) = 10Q$$

$$\Rightarrow q_2^* = \frac{2390 - \left(\frac{2380 - q_2^*}{2}\right)}{2}$$

$$\Rightarrow 2q_2^* = 2390 - \frac{2380}{2} - \frac{q_2^*}{2}$$

$$\Rightarrow q_2^* = 800$$

$$\Rightarrow q_1^* = \frac{2380 - q_2^*}{2} = \frac{1580}{2} = 790$$

$$Q^* = q_1^* + q_2^* = 1590, \quad p^* = 2400 - 1590 = 810$$

Some additional takeaways

Competition and price-taking

- The market demand curve measures the relationship between the market price and the total amount of output sold by all producers
  - Depends on behavior of consumers
- The demand facing an individual firm measures the relationship between the market price and the output of that individual firm
  - Depends on behavior of consumers *and* the other firms
- Under monopolistic competition, these are exactly the same
- In microeconomics, we usually motivate the idea of price-taking by describing a market that has so many firms that no single firm can produce enough to affect the market price on their own
- But under Bertrand competition, prices will be pushed downward to the marginal cost of the second most efficient producer (not unlike a reverse auction)
- While under Cournot competition… this is a problem set question

Competition: Bertrand vs. Cournot

- Cournot: facing a common price, the market supply is determined by the firms' individual choices of quantities to produce
- Bertrand: One firm takes the whole market (except if there's a tie for most efficient producer in which case we assume they split evenly)
- These are not mutually exclusive theories: they are just more applicable to some markets vs. others
  - Bertrand better describes markets where firms are very mobile in their production decisions: they can adjust production levels and prices to extremely responsive and knowledgable consumers very quickly so as to undercut their opponent
  - Cournot better describes markets where production decisions are somewhat binding and made in advance: there is an element of commitment to those quantities that allow differently efficient producers to co-exist

Competition “in real life”

- Nor are they exhaustive: sometimes neither of these is a satisfying model of competition!
  - Bertrand competition hinges on the threat that the next most competitive firm can enter the market if the incumbent charges a higher price than their marginal cost
  - Amazon, Uber, Airbnb and predatory pricing
  - Lots of alternative theories and one of the most active and rigorous areas of research in all of economics
- The general lesson here is that competition is welcome because it redistributes monopolist rents to consumers and prevents deadweight losses associated with higher prices and lower production
- In particular, the power of competition is such that it incentivizes firms who could otherwise split all the consumer surplus between them to instead race to a less extractive equilibrium

Imperfect competition: where does it come from?

- Barriers to entry
  - Exclusive production rights: patents, utilities
  - Secrecy (privately known technology)
  - Economies of scale
    - The firm with the lower marginal cost completely dominates the market under Bertrand competition
    - If a product exhibits increasing returns to scale, this means the largest producers will tend to dominate
    - Hard for anyone to make inroads on a large incumbent
  - Politics
    - Lobbying
    - Protectionism (subsidies and tariffs)
- Consolidation: Mergers and acquisitions
- Collusion and cartels