MIT 14.01: Principles of Microeconomics
Sp 2025, Lecture 14: Imperfect Competition (part I)

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Plan for Today

- Leaving perfect competition behind...
- What is different about imperfect competition?

Imperfect Competition

- Our study of markets so far has always assumed perfectly competitive markets:
    - Any buyer or seller is so small that the impacts of their decisions (i.e. how much to buy/sell) have no impact on market prices
- The premise that most sellers are small certainly seems unrealistic in many market settings
    - E.g. internet search (2 big firms?), social media (3 big firms?), cars (15 big firms?), home internet in Boston (4 firms?), supermarkets within 1 mile of MIT (5 firms?)
- And as we saw in Lectures #5 and #12, the absence of perfect competition may have policy consequences:
    - Perfect competition (along with other conditions) $\Rightarrow$ Pareto Efficiency
    - Does imperfect competition $\Rightarrow$ Pareto inefficiency?

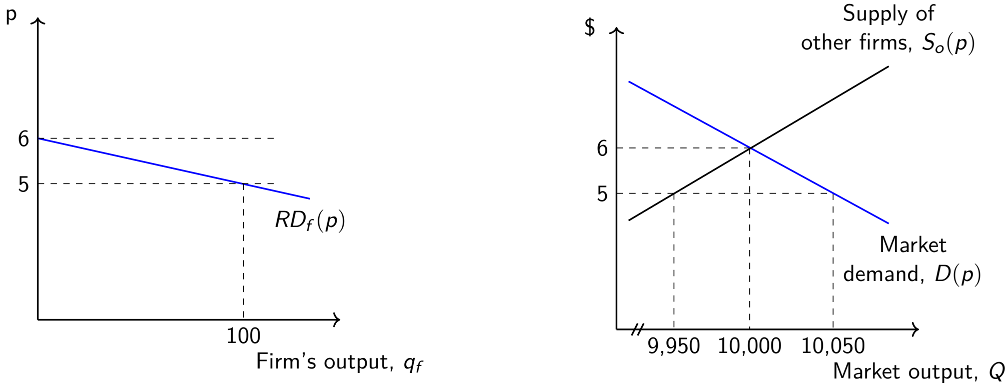
Revisiting "Perfect" Competition

- What did we really mean by a perfectly competitive market?
  - One version is: "each firm takes the market price as given"
  - This is the same as saying that each firm faces a perfectly elastic demand curve
- A more general way of thinking about this (which we will use in our study of imperfect competition) is that *every* firm faces some *residual demand* curve:

$$\underbrace{(\text{residual demand})_f}_{RD_f(p)} = \underbrace{(\text{market demand})}_{D(p)} - \underbrace{(\text{what other firms will supply})}_{S_o(p)}$$

- A more precise metaphor for perfect competition is then to suppose firm f is in a setting where at any market price p:
  - The consumers will demand $D(p)$
  - The "other" firms will always supply $S_o(p)$
  - So firm f faces the residual demand of $RD_f(p) = D(p) - S_o(p)$
  - So with N_F identical firms, the RD_f elasticity is: $\varepsilon_{RD_f,p} = N_F \varepsilon_{D,p} - (N_F - 1)\varepsilon_{S_o,p}$
  - As $N_F \to \infty$ we get $\varepsilon_{RD_f,p} \to -\infty$
  - So with "small" N_F the quantity that f sells will affect p, but for "large" N_F any such effects are tiny, which justifies the perfect competition approximation

Revisiting "Perfect" Competition



- In this simple example, the elasticity of residual demand $RD_f(p)$ at $p = 5.5$ is $\varepsilon_{RD_f,p} = (-100)(5.5/50) = -11$, but the elasticity of market demand $D(p)$ is only $\varepsilon_{D,p} = (-50)(5.5/10025) = -0.03$
- That is, firm f's decision of how much to produce will have a (relatively) small effect on the market price

Profit-Maximization Subject to a Residual Demand Curve

- What will firm f do when it faces the residual demand curve $RD_f(p)$?
  - NB: The question of "what will the $RD_f(p)$ be?" can be complicated in models of imperfect competition, and this will be our focus below and in Lecture #15
  - But for now we can ask what the firm will do whatever $RD_f(p)$ turns out to be...

- Firm f will continue to maximize profits, but now rather than taking p as given it will take the function $RD_f(p)$ as given, as a constraint

- If the firm's cost function is known to be $C_f(\cdot)$ then the Π_f-max problem is:

$$\max_{q_f} pq_f - C_f(q_f) \quad \text{s.t.} \quad q_f = RD_f(p)$$

- Or, if we let the firm's inverse residual demand function be denoted by $p = RD_f^{-1}(q_f) \equiv P_f(q_f)$ then can write this as an unconstrained problem:

$$\max_{q_f} P_f(q_f)q_f - C_f(q_f)$$

Profit-Maximization Subject to a Residual Demand Curve

- What will the solution look like? A pair (q_f^*, p^*) that satisfy the FOC:

$$MR_f(q_f^*) = MC_f(q_f^*) \quad \text{with} \quad MR_f(q_f^*) \equiv \frac{d(pq_f)}{dq_f} = p^* + q_f^* \frac{dP_f(q_f^*)}{dq_f}$$

- The case of perfect competition (Lecture #3) is a special case of this in which the firm's q_f has no effect on p (so p^* is the given p), hence $\frac{dP_f}{dq_f} = 0$ and:

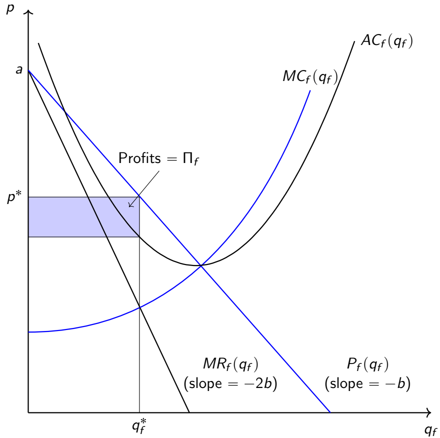
$$MR_f(q_f^*) = p \quad \text{and hence} \quad p = MC_f(q_f^*)$$

- But now in the imperfectly competitive case we have:

$$MR_f(q_f^*) = \underbrace{p^*}_{\substack{\text{extra marginal revenue} \\ \text{from selling one more unit}}} + \underbrace{q_f^* \frac{dP_f(q_f^*)}{dq_f}}_{\substack{\text{lost revenue on all infra-marginal} \\ \text{units from sliding down RD curve}}}$$

- SOC? Need (for $\frac{dMC_f(q_f^*)}{dq_f} \geqslant 0$) $RD_f(q_f^*)$ to be elastic (i.e. $\varepsilon_{RD_f,p}(p^*) < -1$).
- Interior? Shut down (i.e. set $q_f^* = 0$) if $p^* < AVC_f(q_f^*)$, as in Lecture #9.

Profit-Maximization Subject to a Residual Demand Curve



- Drawn for case of linear RD_f (with inverse RD_f given by $P_f(q_f) = a - bq_f$)
  - Linear demand always has property that $MR_f(q_f)$ has same intercept, but slope that is twice as big (in abs. val.)
- FOC: produce at q_f^*, i.e. where $MR_f(q_f^*) = MC_f(q_f^*)$
  - And then determine p^* by inverse demand curve: $p^* = P_f(q_f^*)$
- Check SOC: is $\varepsilon_{RD_f,p} < -1$?
  - Yes. This turns out to always be true for linear demand ($\varepsilon_{RD_f,p} > -1$ below 45-degree line, but $MR = 0$ at that point).
- Shut down? Is $p^* < AVC_f(q_f^*)$, i.e. $\Pi_f < 0$?
  - No. Here FC is non-sunk, so $AC = AVC$, and as drawn AC_f is lower than P_f at q_f^*.

Markups, Elasticities, and Market Power

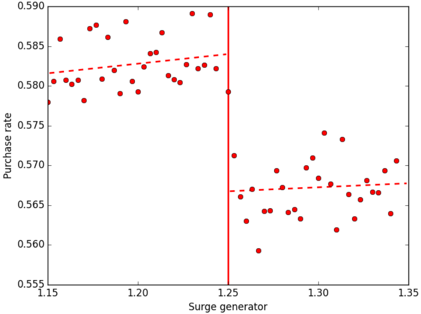
- Two definitions:
  1. *markup* ("price is marked up over marginal cost"): $\mu_f \equiv p^* - MC_f(q_f^*)$
  2. *price-cost margin* (aka *Lerner index*): $LI_f \equiv \frac{p^* - MC_f(q_f^*)}{p^*} = \frac{\mu_f}{p^*}$

- Then write the firm's FOC in elasticity form (using fact that $\varepsilon_{RD_f^{-1},q} = \frac{1}{\varepsilon_{RD_f,p}}$) as:

$$\frac{\mu_f}{p^*} = LI_f = \frac{1}{\left|\varepsilon_{RD_f,p}\right|}$$

- Intuition:
  - Higher elasticity (in abs. value) of RD $\Rightarrow$ lower markup rel. to price
  - We say that high *LI* implies that the firm has a lot of *market power* – its q sold has a relatively large effect on its market
  - Under perfect competition, firm has no market power (i.e. $\mu_f = L_f = 0$ since $\left|\varepsilon_{RD_f,p}\right| \rightarrow \infty$ under perfect comp.)

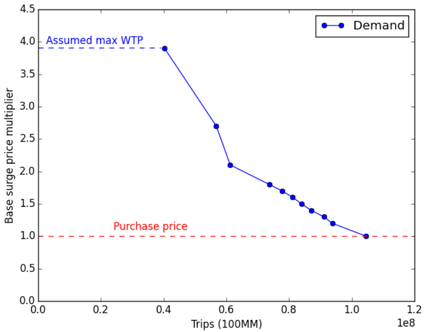
What is Uber's Residual Demand Elasticity?



Cohen et. al. (2016)

- Uber's internal algorithms calculate their optimal "surge price" multiplier over the base price (at any location and time) as a continuous number
- But then (in 2015) they offered the consumer a rounded up/down version
  - E.g. 1.2× switches to 1.3× as the continuous number crosses 1.25
- Authors use this to conduct a regression discontinuity analysis to figure out Uber's residual demand curve: how a change in the price offered consumers affects how much they'll buy
  - Probably short-run elasticity: consumers may already be locked into using ride-share when they learn about the surge

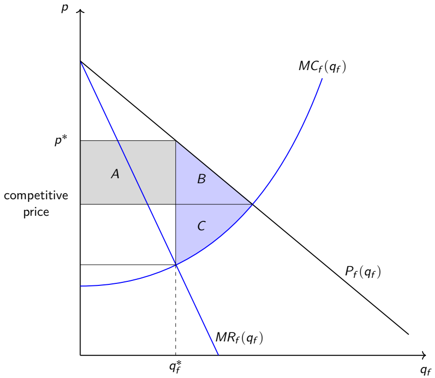
What is Uber's Residual Demand Elasticity?



Cohen et. al. (2016)

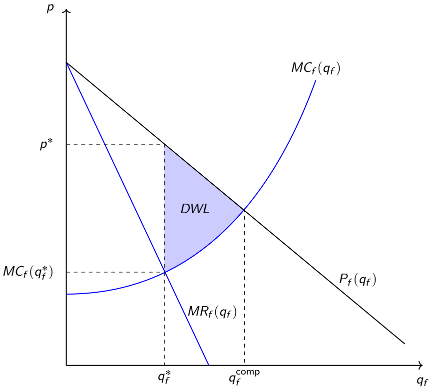
- This figure shows the result of such discontinuity estimates at lots of different surge price multipliers
- Lowest implied $\varepsilon_{RD_f,p}$ here is (eyeballing) $\approx (0.95 - 1.05)/(1.25 - 1) = -0.4$
- This violates the SOC (which requires $\varepsilon_{RD_f,p} < -1$)! Was Uber under-pricing?
- Likely engaged in (long-run) dynamic pricing. Price low now so as to price higher later. Why price low now?
  - Build up customer (or driver) loyalty/experience (and political support)
  - Improve technology through dynamic scale

The Inefficiency of Market Power



- Recall the FWT (Lectures #4 and #12):
  - Perfect competition leads (in absence of other market failures) to a PE allocation that maximizes total (firm + consumer) surplus
- Why does imperfect competition do worse?
  - Firm f uses its market power to capture some of the consumer surplus (to gain A), but in the process it destroys some total surplus (i.e. creates some deadweight loss, B+C)
- But if firm f could somehow capture all of the total surplus then imperfect competition would actually be PE
  - So the problem isn't market power, *per se*
  - The problem is the semi-potent market power in which firm f can post only a single price p to the entire market – more on this below

How Large is the Deadweight Loss Due to Market Power?



- Notice how the markup μ_f is a "wedge" between the consumer price p^* and the firm's $MC_f(q_f^*)$
  - Like how a tax (as in Lecture #5) is a "wedge" between the consumer and producer price
- Just as with a tax, a markup causes DWL:
  - At q_f^* there are consumers with high WTP, and this firm has low MC – but they don't trade because the firm finds (thanks to its market power) it better not to
- As in Lecture #5, can show that DWL "Harberger triangle" approximation is:

$$DWL = \frac{1}{2}\mu_f(q_f^{\text{comp}} - q_f^*)$$

- With constant MC_f: $DWL = \frac{1}{2}\mu_f q_f^*$

Example: Linear Residual Demand

- Suppose that firm f has zero costs $C_f(q_f) = 0$ and faces a linear residual demand curve given by $RD_f(p) = \frac{a-p}{b}$
- What will be the firm's optimal price and quantity pair (p^*, q_f^*)?
  - Work out the $\varepsilon_{RD_f,p} \equiv \frac{p}{q_f}\frac{\partial RD_f}{\partial p} = -\frac{p}{bq_f}$
  - Solve the FOC $\frac{p^* - MC_f}{p^*} = \frac{1}{|\varepsilon_{RD_f,p}|} \iff |\varepsilon_{RD_f,p}| = 1 \iff p^* = bq_f^*$
  - Use RD_f (i.e. $bq_f^* = a - p^*$) to solve: $p^* = a - p^* \iff p^* = \frac{a}{2}$ and $q_f^* = \frac{a}{2b}$
  - No need to check SOC (due to linear demand) or shut-down (due to zero costs)
- What is the firm's markup and profit?
  - $\mu_f \equiv p^* - MC_f(q_f^*) = p^* = \frac{a}{2}$ and $\Pi_f = q_f^*(p^* - AC_f(q_f^*)) = p^* q_f^* = \frac{a^2}{4b}$
- What will be the DWL due to this firm's market power?
  - We know $q_f^{\text{comp}} = \frac{a - p^{\text{comp}}}{b}$ and $p^{\text{comp}} = MC_f = 0$, so $q_f^{\text{comp}} = \frac{a}{b}$
  - So $DWL \equiv \frac{1}{2}\mu_f(q_f^{\text{comp}} - q_f^*) = \frac{1}{2}(\frac{a}{2})(\frac{a}{b} - \frac{a}{2b}) = \frac{a^2}{8b}$
  - Can verify that this is also $= \frac{1}{2}\mu_f q_f^*$ since this is a constant MC case

What is the Firm's Supply Function?

- Recall, for a competitive firm (e.g. Lecture #3 or #9) we used the firm's profit-maximization problem to solve for the firm's supply function:
  - How much q_f will the firm produce at any given market price p?
  - The answer is the supply function $q_f = S_f(p_f)$
  - And this was true for any demand function $D(p)$ (of course $D(\cdot)$ would help determine the equilibrium p but the supply function does not depend on $D(\cdot)$)

- With imperfect competition this doesn't make any sense – the firm chooses both p and q_f at the same time

- It's as if we have a supply "dot"—a point in the (p, q_f) space—not a supply "function"

From Residual Demand to Specific "Market Structure"

- Everything so far has taken $RD_f(p)$ as given - but where does $RD_f(p)$ come from?
- Since $RD_f(p) = D(p) - S_o(p)$, the real question for today's lecture (about competition, not demand $D(p)$) is: where does $S_o(p)$ come from?
- This is the question of *market structure* – how does firm f compete with rivals?
- This is what we will cover from now on (and in the next lecture)

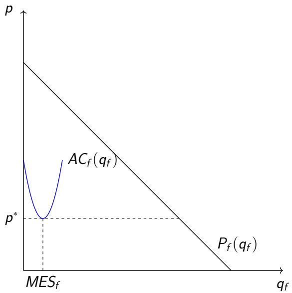
Monopoly

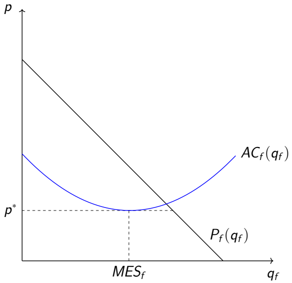
- *Monopoly*: when there is only one firm in the market – and there is no threat of entry from some other potential firm(s)
- In the context of residual demand, this is like saying that $S_o(p) = 0$
- So the case of monopoly is a relatively simple market structure to consider

Example: Monopoly with Linear Demand

- Suppose that firm f is a monopolist with zero costs $C_f(q_f) = 0$. The firm faces the market demand curve of $D(p) = \frac{a-p}{b}$.
- What will be the firm's optimal price and quantity pair (p^*, q_f^*), markup, and profits? And how much DWL is created due to the firm's monopoly power?
  - We did this above!
  - The whole point of thinking about imperfect competition via each firm's residual demand is that all firms are monopolists over their own residual demand
  - So the answers are exactly the same as above since this monopolist is facing the same RD (and has the same MC) as the firm in the example above
  - That is: $p^* = \frac{a}{2}$, $q_f^* = \frac{a}{2b}$, $\mu_f = \frac{a}{2}$, $\Pi_f = \frac{a^2}{4b}$, $DWL = \frac{a^2}{8b}$

Why Would Monopoly Arise?





- One answer is *barriers to entry*:
  - Due to policy (e.g. state monopoly like USPS, patent/copyright, or regulation/licensing)
  - Or due to a deliberate strategy of incumbent to deter entry (e.g. consumer switching costs)

- Or could be a *natural monopoly*:
  - High minimum efficient scale (MES) relative to demand
  - Here, a second firm could not make positive profits, unlike in the figure on the left

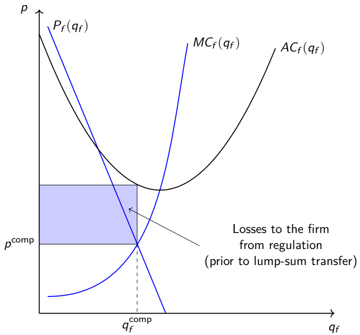
Costs and Benefits of Monopoly (and Market Power More Generally)

- Costs:
  1. The DWL we saw earlier (true for any imperfectly competitive firm)
  2. *X-inefficiency*: lack of competition may dampen internal incentives to be good at cost-minimizing (i.e. firm may waste resources)
  3. *Rent-seeking*: If monopolistic profits exist, potential firms might be willing to "fight" (i.e. waste resources on things that are no benefit to consumers) for the chance to become the lucky monopolist

- Benefits:
  1. Provision of goods with high MES relative to demand may require a markup (i.e. the DWL that comes with the markup may be less bad than no product being sold at all)
  2. Exploitation of IRTS (e.g. avoid duplication of a fixed cost)

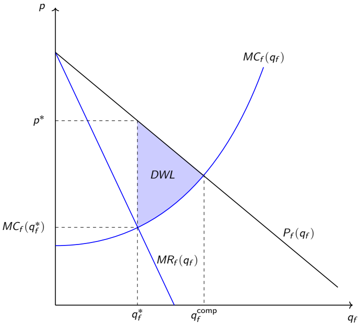
- But note that benefits only apply to "natural" monopoly sources. If market power arises due to policy or deliberate barriers to entry it is more likely that costs outweigh benefits.

Policy to Remedy a Natural Monopolist



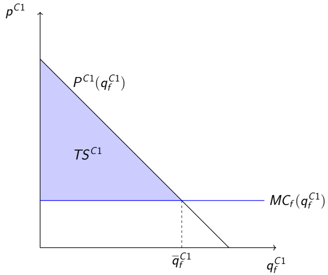
- Our first example of corrective policy
  - Introduce one market failure (policy) to combat another (market power) and get to a PE ($DWL = 0$) allocation – "two wrongs make a right!"
- *Regulation*: force the monopolist to sell amount q_f^{comp} such that $p^{comp} = MC_f(q_f^{comp})$
  - The firm may have $\Pi_f < 0$ at that point (as in this figure, since MES is outside $P_f(q_f)$), so also have to pay the firm a lump-sum transfer (so they break even)
- *Subsidy* s to (e.g.) consumption:
  - Ensure cons. price (i.e. $p^c = p - s$) is $p^c = MC_f(q_f)$
  - Perhaps surprising. But recall the whole problem of market power is the firm holding back on production.
- Both a good idea in theory but challenging in practice (hard for government to know firm's cost function)

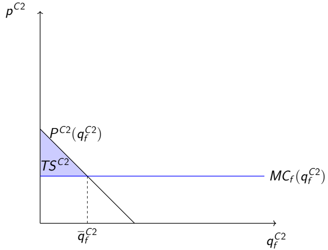
Price Discrimination



- Any imperfectly competitive firm maximizes its profits subject to the constraint that it faces some $RD_f(\cdot)$
- But a "deeper" constraint we have imposed is that it can only offer one particular price function to the consumers in the market:
  - Linear: "no matter the quantity bought, the price is p"
  - Common: "no matter who you are, the price is p"
- That is, it cannot *price discriminate* in a way that deviates from common and linear pricing
  - Why? Maybe a *resale market* exists that can easily arbitrage away any attempts by the firm to discriminate
- This constraint on the possible price functions means that the firm forgoes some of the total surplus in its market. And that is the deep root of the DWL.

“Perfect” (aka “First Degree”) Price Discrimination





- Suppose this firm *could* offer a different price to each consumer (and $N_C = 2$). What would it do?
  - Work out $\bar{q}_f^{C1}$ such that $MC_f(\bar{q}_f^{C1}) = P^{C1}(\bar{q}_f^{C1})$. Make price-quantity offer to C1 of $\bar{q}_f^{C1}$ and $p^{C1} = TS^{C1}/\bar{q}_f^{C1}$.
  - And analogously for C2: $\bar{q}_f^{C2}$ and $p^{C2} = TS^{C2}/\bar{q}_f^{C2}$
  - (But this is only feasible if resale between 1 and 2 is forbidden.)
- Then the firm captures all the surplus in the market, so this is actually PE (despite imperfect competition)
  - But highly unequal! ($PS = TS$, $CS = 0$)
- Note the paradox of technological progress:
  - Invention of a new technology called “resale” in this environment would be *bad* for total surplus – go from perfect p. discrim. (PE) to monopoly ($DWL > 0$)
  - This can happen in settings with market failures (but not in settings in which the FWT holds)

Real-World Price Discrimination

- In reality, firms can't perfectly prevent resale, so other forms of imperfect price discrimination often get used in imperfectly competitive settings

- *Third-degree* (aka *multi-market pricing*):
  - Suppose the firm has the ability to segment consumers into groups (not perfectly separating ones) g – here assuming no resale across groups
  - Then can just charge each g a different price p^g reflecting the FOC $L_f^g = \frac{1}{|\varepsilon_{RD_f^g, p}|}$
  - E.g. discount codes, financial aid, airfare for a Saturday stayover

- *Second-degree* (aka *screening*):
  - Firm could offer a *menu* of options to the consumer – here assuming no resale across consumers, but firm doesn't know who is who
  - Examples of menus:
    - A two-part tariff (e.g. a dozen donuts costs same as about 6.5 single donuts)
    - Slightly differentiated versions of product (e.g. refundable airfares, fairtrade coffee)
    - Bundles/tie-ins (e.g. streaming services don't let you pay per show on offer)
  - Firm wants low-elasticity consumers to *self-select* into higher-priced options

Concluding Remarks

- **Key concepts from today's lecture:**
  - Perfect competition: firm faces perfectly elastic residual demand
  - Imperfect comp.: RD is somewhat inelastic (firm has some market power), so firm sells less than under perfect competition and charges a markup over marginal cost
  - Lerner index: ratio of markup to price
  - Firm's FOC: Lerner index = inverse of elasticity of RD (in abs. val.)
  - Markups cause DWL (and usual Harberger triangle formula applies)
  - Imperfectly competitive firm has no supply function (chooses both price and quantity)
  - Monopoly: firm is only seller in market, so RD is just market demand
  - Natural monopoly has costs (DWL) but also benefits (fund IRTS activities)
  - Perfect price discrimination is Pareto Efficient
  - Realistic price discrimination: third-degree (firm can segment consumers into separate markets) and second-degree (consumers self-select into choice from a menu of price-quantity/quality options)

- **Next lecture:**
  - Oligopoly: strategic interactions between imperfectly competitive firms