

H1 (selected)

Elasticity: measure of price sensitivity

Own-price elasticity of demand $\frac{\% \Delta Q}{\% \Delta P}$: the % change in quantity demanded for a 1% change in its price. Always negative by Law of Demand.

$|E| < 1$ Inelastic
 $|E| > 1$ Elastic

Cross-price elasticity of demand $\frac{\% \Delta Q}{\% \Delta P_2}$: the % change in quantity demanded for a 1% change in another good's price.

> 0 SUBSTITUTES (wine & beer)
 < 0 COMPLEMENTS (popcorn & beer)

Network Externality: The product is more valuable to you if it is used by others. To maintain n.e., (1) establish switching costs (2) interoperability (weakens direct n.e.)

- Direct n.e.: Emails – requires other users
- Indirect n.e.: Windows – requires complements like software developed for Win.

Positive N.E.: the value of a product increases with the # of users (higher WTP). Network goods. Makes demand *more elastic* so an aggressive pricing strategy becomes more profitable. **Negative N.E.:** e.g. luxury goods.

Monopoly: a single firm is in the market.

Marginal Cost (MC): How cost changes as output Q changes: for 1 unit, $Cost(Q) - Cost(Q-1)$; for more units, $\frac{\Delta Cost}{\Delta Q}$; and for small changes, $\frac{dCost}{dQ}$.

Fixed costs don't enter MC.

Marginal Revenue (MR):

$$MR = \frac{\Delta Rev(Q)}{\Delta Q} = P(Q) + Q \frac{\Delta P(Q)}{\Delta Q}$$

In order to sell more units, the price must be lowered for all units. Decrease price results in: **gain** in Rev from Q increases + **loss** in Revenue from P reduction for all units.

If demand curve linear, **MR has same intercept and twice the slope.** $P(Q) = 100 - Q \rightarrow MR = 100 - 2Q$

price $P^* = P(Q^*)$ Does not depend on the level of demand.

Mark-up Formula: resulting from profit-max, P^* satisfies: $\frac{P-MC}{P} = -\frac{1}{\epsilon}$ (ϵ is the demand elasticity). **Relatively more elastic markets** (markets with more price-sensitive consumers) will face smaller markups (i.e., lower prices if costs are the same across markets).

Profix Maximization:

optimal Q^* when $MC(Q^*) = MR(Q^*)$. Then solve for optimal

Costs

Fixed Cost: costs that don't vary with the level of output (Q). **Variable Cost:** costs that vary with the level of output (Q). The fixed vs variable cost distinction depends on the business question and on the time horizon. E.g., all inputs (including capacity) are variable in the "Long Run"

Economies of Scale: average cost ($\frac{TC}{Q}$) falls with higher Q.

H2

Supply and Demand

Demand: how much consumers will buy at a particular price; describes consumers' willingness to pay (WTP). $Q_d = a - b \cdot P$

Supply: how much producers will provide at a particular price; describes producers' willingness to accept (WTA) / the industry's aggregate marginal cost curve (i.e. Market supply is the sum of the individual firm supply curves). $Q_s = c + d \cdot P$

Remember to always check whether we need to invert a given function! **Competitive Markets:** Individual firms and consumers don't affect prices (i.e. they have no market power and are price takers)

Competitive Market Equilibrium:

$Q^* = Q_s(P^*) = Q_d(P^*)$ In these markets, **prices are determined** by:

- the **"marginal buyer"** $P^* = WTP$: who would leave the market if the price were any higher, and
- the **"marginal seller"** $P^* = WTA$: who would leave the market if the price were any lower

Producer Surplus (PS): = Revenue - Total WTA = Revenue - Total Variable Cost (area below price and above supply.)

Without market power, **firm-level inverse demand curve is perfectly elastic** (i.e. horizontal) **at the market price.** Market sets $MR(Q) = P$. **Firm's supply curve is its MC curve.** Firm profit

maximized when:

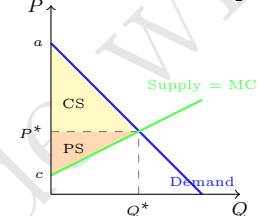
Market $P = MR(Q^*) = MC(Q^*)$, provided the firm is operating at all. *Not to be confused with the MR discussed in H1 Monopoly Pricing!*

First Welfare Theorem: Competitive markets are **efficient** (i.e. they maximize total surplus = CS + PS).

- Assumes no distortions such as market power, info frictions, or *externalities*.
- Under perfect competition, all trades involving consumers who value the good more than the marginal cost associated with producing an additional unit of the good are realized.

Welfare is maximized: by the perfectly competitive outcome when there are not externalities. To maximize total welfare, we want

- Consumers get: $CS = \frac{1}{2}(a - P^*)Q^*$
- Producers get: $PS = \frac{1}{2}(P^* - c)Q^*$



Competitive markets

maximize total surplus.

Distortion e.g.: Pricing with market power

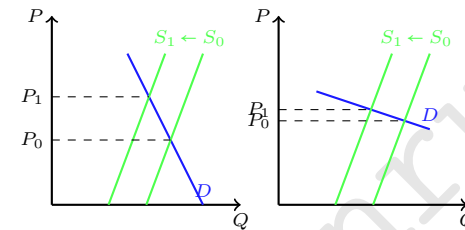
Deadweight Loss (DWL): Lost surplus due to a distortion away from perfect competition.

$DWL = CS + PS - TS$ i.e. Maximum surplus - Achieved surplus. DWL offers an opportunity to "grow the pie", represents the value proposition for many firms.

In the left graph: DWL will be generated

- if $Q < Q^*$ because there will be consumers that value the product at above the marginal cost
- if $Q > Q^*$ because there will be consumers consuming the product even though their $WTP < MC$

Cost Shock: if one side of the market is highly elastic, then they can avoid shocks (and pass on any taxes / transaction fees).

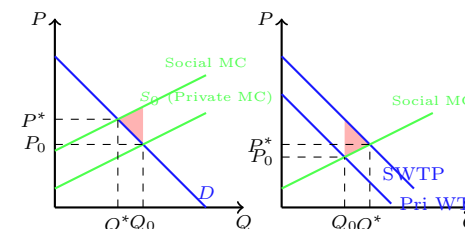


Externalities

Externality: an activity generates it when it imposes a cost or benefit on a third party not involved in the activity. An externality is a **market failure** because the market does not account for the full cost or benefit of the activity – left alone the perfectly competitive market will not maximize welfare.

- **Negative ext.:** costs born by society; e.g. pollution, congestion, noise, contagion. External costs (negative ext.) \Rightarrow firms produce too much. **Sol.:** tax the product by the externality amount (to shift up the supply curve); taxes "internalize" the externality and reduce quantity.
- **Positive ext.:** benefits born by society; e.g. education, vaccines, R&D (ideas). External benefits (positive ext.) \Rightarrow firms produce too little. **Sol.:** subsidize customers the externality amount (to shift up the demand curve)

Without solutions (e.g. regulation, taxes, subsidies, property rights), externalities create DWL.



Tragedy of the Commons: When a resource is held in common, individuals have no incentive to conserve it. This is an example of a negative externality since others' access impairs everyone's use of the resource. Individual will overuse.

Solution: assign property rights, regulate, or tax; joint ventures also allow for collaboration that "internalizes" the externality.

Coase Theorem: If property rights are well-defined and transaction costs are low (or none), the efficient solution occurs regardless of who holds the property rights. Cap and Trade policies set up a market to make this bargaining easier.

Distributional Consequences:

1. the distribution of the burden of the externality,
2. distribution of the costs to correct the externality, and
3. distribution of the burden of externality after policy intervention.

E.g. the R&D market: think of the demand curve originating from the profits that firms here would get from innovating, and thus representing the **private** demand for R&D. The MC curve (supply) represents the private MC of research and development. We will assume that the private MC of R&D equals the social MC. Demand: $Q_{private, d} = 100 - 2P$; supply: $Q_s = \frac{P}{2}$.

1. **Competitive market equilibrium:**

$$Q_{private, d} = Q_s \Rightarrow 100 - 2P = \frac{P}{2} \Rightarrow \begin{cases} P^* = 40 \\ Q_s^* = 20 \end{cases}$$

2. **Total amount spent on R&D:**

$$P^* \cdot Q_s^* = 40 \cdot 20 = 800$$

3. Now suppose that not only does the firm paying for the research and development benefit from the R&D, but some of these benefits spillover to other firms. In particular, economists have calculated that every unit of R&D done by a firm benefits other firms by \$30. **What is the society demand curve for R&D:** Inverse demand curve: $P = 50 - \frac{Q}{2}$. The positive externality implies that the willingness to pay for R&D increases by \$30 everywhere. So the social inverse demand curve (SWTP) is

$$P = 80 - \frac{Q}{2} \xrightarrow{\text{inverse}} Q_{society, d} = 160 - 2P$$

4. **Ways to overcome this positive externality:**

- (a) Implementing patent system to allow the innovating firm to capture more of the benefits from their R&D.
- (b) Subsidizing R&D; esp. for hard, basic science.

Game Theory

Each player's objective is to maximize their payoff, not to beat their opponent.

Situation of strategic interdependence: a firm's best choice depends on what its rivals do and how it expects rivals to react to its actions.

Strategy: a "complete contingent plan" that specifies what a player will do at every possible decision node.

Best response: the strategy with the highest payoff in response to the strategies its rivals can take.

Dominant Strategy: a strategy that is best for a player to follow regardless of the strategies chosen by other players. **It's a player's best response to any strategy the other player might choose.**

Iterated dominance: sometimes it's possible to narrow things down by eliminating strategies that known never a best choice for rival, and also strategies that are never a best choice for rival if they eliminate the possibility that you will play something that's never a best choice for you ... **E.g.:** guess half of the median game.

Nash Equilibrium: a set of strategies, one for each player, such that no player has an incentive to change their strategy given what the other players are doing. I.e. **each player's strategy is a best response to the strategies chosen by the other players.**

1. For Player 1: In each column, mark the largest payoff for Player 1.
2. For Player 2: In each row, mark the largest payoff for Player 2.
3. A cell is a Nash equilibrium if both payoffs in that cell are marked.
4. **Verify:** For each candidate cell, confirm that:
 $\begin{cases} P_1(\text{row}) \geq P_1(\text{other rows}) \\ P_2(\text{col}) \geq P_2(\text{other cols}) \end{cases}$

Schwab vs E-Trade pricing game:

	Monopoly Price	Lower Price	Lowest Price
Monopoly Price	10, 10	5, 12	0, 9
Lower Price	12 , 5	6, 6	2, 8
Lowest Price	9, 0	8 , 2	3 , 3

- **No dominant strategy** for either firm. All colors would be in one row/column.
- One N.E.: (Lowest Price, Lowest Price). There may be more than one N.E. if both colored!

Bertrand model/trap of price competition:

Each firm's best response is to undercut its rival \Rightarrow N.E. = price = MC (i.e. a price war). **Sol.:**

- **Repeated interactions:** (later)...
- **Product differentiation:** when consumers have heterogeneous preferences; can be both **horizontal** (differentiated by quality; e.g. Coke vs Pepsi) and **vertical** (differentiated by price; e.g. faster vs slower computers).

Horizontal Differentiation: Linear

City/Hotelling Model: Each consumer has a location x and these locations are evenly distributed along a line from 0 to 100. One firm is located at each end of the line, and each firm sells a product that every consumer values at v . (Note: We can also allow for vertical differentiation in this model by setting a different v for each firm.)

- Consumers choose where to buy based on price and travel cost; t is the marginal cost of travel.
- To solve this model, we identify the indifferent consumer at location x^* . All consumers with $x \leq x^*$ will visit firm 1 (i.e., the firm at location 0) and all consumers with $x \geq x^*$ will visit firm 2 (i.e., the firm at location 100).
- Consequently, x^* is the **market share** (in percentage terms) for firm 1, and $100 - x^*$ is the market share (in percentage terms) for firm 2.

- The consumer at x^* receives a payoff of $v - (p_1 + tx^*)$ if they buy from firm 1 and a payoff of $v - (p_2 + t(100 - x^*))$ if they visit firm 2. We therefore have: $v - (p_1 + tx^*) = v - (p_2 + t(100 - x^*)) \Rightarrow x^* = 50 + \frac{p_2 - p_1}{2t}$

Normalized demand:

$$\begin{cases} Q_1(p_1, p_2) = x^* = 50 + \frac{p_2 - p_1}{2t} \\ Q_2(p_2, p_1) = x^* = 50 + \frac{p_1 - p_2}{2t} \end{cases}$$

$$\begin{cases} \Pi_1(p_1, p_2) = p_1 \left(50 + \frac{p_2 - p_1}{2t} \right) \\ \Pi_2(p_2, p_1) = p_2 \left(50 + \frac{p_1 - p_2}{2t} \right) \end{cases}$$

- **Note:** If you are told that there are N consumers evenly distributed along the line, you can compute the actual demand and profits by multiplying these expressions by $N/100$.

- Given the price chosen by its competitor, each firm then **best responds** by choosing a price that maximizes its profits.

Variation of horizontal diff.: two food trucks are located at the endpoints of a "linear city." Truck 1 is located at position 0, and truck 2 is at position 100. The gross value two trucks' products: $v_1 = 300$, $v_2 = 260$. Assume the cost of walking is $t = 1$ per step.

- Total cost for the 2 products of consumer at position x : Firm 1's product: $300 - p_1 - x$; Firm 2's product: $260 - p_2 - (100 - x) = 160 + x - p_2 \Rightarrow$

- indifferent customer position: $x^*(p_1, p_2) = 70 + \frac{p_2 - p_1}{2}$

- market shares: $\begin{cases} X_1(p_1, p_2) = 70 + \frac{p_2 - p_1}{2} \\ X_2(p_2, p_1) = 30 - \frac{p_2 - p_1}{2} \end{cases}$

- profits: $\begin{cases} \Pi_1(p_1, p_2) = p_1 \left(70 + \frac{p_2 - p_1}{2} \right) \\ \Pi_2(p_2, p_1) = p_2 \left(30 - \frac{p_2 - p_1}{2} \right) \end{cases}$

- If the two trucks charge identical prices, indifferent consumer: $300 - p - x^* = 160 + x^* - p \Rightarrow x^* = 70$
- Payoff matrix associated with following price choices:

$$\begin{cases} p_1 = (110, 160, 210) \\ p_2 = (50, 100, 150) \end{cases} : \text{Plug prices into}$$

$\Pi_1(p_1, p_2)$ and $\Pi_2(p_2, p_1)$ as payoffs

$\downarrow p_1$	$p_2 \rightarrow 50$	100	150
110	4400, 3000	7150 , 3500	9900, 1500
160	2400, 4250	6400, 6000	10400 , 5250
210	-2100, 5500	3150, 8500	8400, 9000

- Only N.E.: ($p_1 = 110, p_2 = 100$)
- Firm 1 chooses a higher price because firm 1 transfers some of its quality advantage into a greater margin, and some into a larger market share

Why would a company pay to make their product lower quality? 1. By crimping the product designed for the low WTP consumers, we were able to extract more surplus from the high WTP consumers. 2. Ryan Air may be willing to pay to lower its quality so that it doesn't compete as hard with British Airways.

Vertical Differentiation: Vertical City Model: Consumers now have heterogeneous preferences for **quality**. This is captured by a parameter θ , which is evenly distributed along a vertical line from 0 to 1.

- Each firm now chooses a quality level q and a price p .
- A consumer with quality preference θ that buys quality q and at price p receives a payoff of $\theta q - p$.
- Suppose that one firm sets a high price p_H and quality q_H , and the other firm sets a low price p_L and quality q_L .

We solve this model by identifying two indifferent consumers:

- A consumer with preference for quality θ_L that is indifferent between buying from the **low-quality** firm and not buying anything.
- A consumer with preference for quality θ_H that is indifferent between buying from the **low-quality** and the **high-quality** firm.

- The consumer with quality preference θ_L receives a payoff of $\theta_L q_L - p_L$ if they buy from the low-quality firm and a payoff of 0 if they buy nothing. Consequently, we have: $\theta_L q_L - p_L = 0 \Rightarrow \theta_L = \frac{p_L}{q_L}$.

- The consumer with quality preference θ_H receives a payoff of $\theta_H q_H - p_H$ if they buy from the high-quality firm and a payoff of $\theta_H q_L - p_L$ if they buy from the low-quality firm. Consequently, we have: $\theta_H q_H - p_H = \theta_H q_L - p_L \Rightarrow \theta_H = \frac{p_H - p_L}{q_H - q_L}$.

- Putting everything together: consumers with:
 - $\theta < \theta_L$ will buy nothing.
 - $\theta_L < \theta < \theta_H$ will buy from the low-quality firm.
 - $\theta > \theta_H$ will buy from the high-quality firm.

Low-quality firm's market share:

$$100(\theta_H - \theta_L)\%$$

High-quality firm's market share:

$$100(1 - \theta_H)\%$$

- **Implication:** Increasing the quality of your product offering isn't always a good thing! If your rival is selling a high-quality good, it may be better to sell a lower-quality good.

Repeated interactions: can facilitate **coordination/collusion**, even w/o explicit communication. **Another possibility for escaping the Bertrand trap.**

- N.E. outcome will arise; i.e. when firms are unable to achieve or sustain coordination, then each firm will best respond to the pricing strategy of the other firm.
- If the firms can perfectly coordinate, then market outcome coincides with the monopoly outcome. (i.e. as if two firms merged into one monopoly) **Best the firms can do.**
- In simulation, prices mainly were above the N.E. but below the monopoly price.

Coordination is easier to sustain when:

- Firms can easily observe the prices set by their rivals.
- Market demand is known and doesn't change over time.
- The number of firms in the market is small.

Repeated Price Competition: firms will

cooperate if $NPV_{\text{cooperating}} > NPV_{\text{undercutting}}$

because:

- Cooperation is particularly rewarding (e.g. high monopoly mark-ups)
- Price wars are particularly costly (e.g. commodities which have low demand elasticities)
- Parties are similar enough to agree with one another on the optimal price
- Parties can monitor and punish undercutting
- Parties care about the future as cooperation provides longer-run benefits

Grim Trigger / Nash Reversion: Cooperate with your rivals but revert to the static Nash equilibrium forever should any firm deviate from the cooperative price. (i.e. If one firm undercuts, the other firm will undercut in the next period.) Less-harsh strategies where parties punish and cooperate over shorter time horizons can also support cooperation (for example, **tit-for-tat**).

\downarrow Firm 1	Firm 2 \rightarrow	Coordinate	Price War
Coordinate		450, 450	200, 650
Price War		650, 200	300 , 300

If the punishment for undercutting is Nash reversion, cooperation forever happens when:

$$NPV_{\text{cooperating}} > NPV_{\text{undercutting}}: 450 + \frac{450}{r} > 650 + \frac{300}{r} \Rightarrow r < 0.75$$

More generally, **collusion is possible when:**

$$r < \frac{\pi_{\text{cooperate}} - \pi_{\text{war}}}{\pi_{\text{deviate}} - \pi_{\text{cooperate}}}$$

Antitrust Laws: regulate market competition, focusing on practices that tend to reduce rivalry between firms (e.g., price fixing and horizontal mergers) as well as those that can foreclose competition, furthering a dominant firm's position (e.g., vertical mergers and exclusive dealing). Price fixing is *per se* illegal, and punishments typically include time in jail. **E.g.:**

- Sherman Act (1890)
- Clayton Act (1914)
- Federal Trade Commission Act (1914)

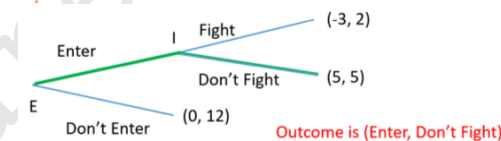
Mergers: reduce the amount of competition, prices trend up. Can also lead to cost efficiencies, prices trend down. Anti-trust policy must weigh these two countervailing effects.

Unilateral Behavior:

- **Predatory Pricing** a firm sets prices below cost to drive rivals out of business. Illegal.
- **Exclusive Dealing** a firm requires a buyer to purchase all of its needs from the seller.
- **Tying** leveraging market power in one market (e.g. operating systems) to gain market power in another (e.g. browser).

Dynamic Games: where players take actions at different points in time. Need to think about what will happen in the future given their current choices.

Backward induction: (in finite games that stop at some point) 1. figure out what will happen at the end of the game, and (2) then work backwards to determine players' earlier choices. Identifies **Nash equilibria** that don't involve non-credible threats.

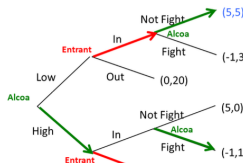


Strategic

Pre-commitment:

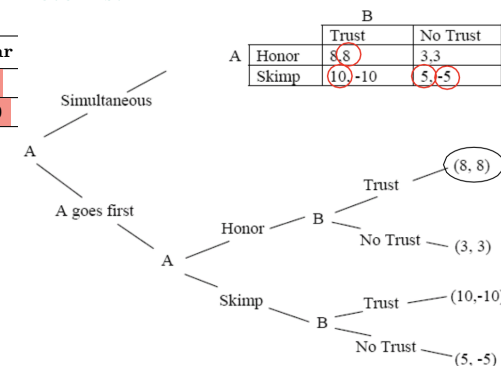
a player makes a choice that commits them to a certain strategy in the future to get rivals to respond in desirable ways. **Eg.:** a firm that builds a large factory to signal that it will produce a large quantity in the future.

- pre-committing aggressive actions: when rivals'll respond by being less aggressive (e.g. capacity)



- vice versa (e.g. price)

Practice Problem: simultaneous vs A pays to move first:



- Simultaneous: A's dominant strategy is "Skimp" (i.e. save money). N.E. is (Skimp, No Trust).
- A would pay up to $8 - 5 = 3$ to go first reaching N.E.: (A: Honor, then B: Trust); 8 is the first-mover payoff; 5 is the simultaneous payoff.

Cournot (quantity competition) vs Bertrand (price competition): Price is lower ($=$ MC) under Bertrand, resulting in greater CS than Cournot.

Stackelberg Model: A sequential game where the leader chooses its output first, and the follower chooses its output after observing the leader's decision. **Key Idea:** The leader commits to a production level, anticipating the follower's best response. **Assumptions:** Both firms produce homogeneous goods and face the same market demand. **Result:** The leader often earns higher profits by influencing the follower's behavior; total output exceeds Cournot equilibrium output.