MONOPOLY AND REGULATION.

Monopoly problem.

Market power ⇒ Seller faces downward sloping demand curve.

If price is raised, seller sells less.

Must reduce price to sell more.
Assume: Market demand curve downward sloping & smooth.

Price elasticity of demand:

\[
\epsilon = -\frac{q}{\Delta p} \cdot \frac{\Delta q}{p} = -\frac{\Delta qp}{\Delta qq} \\
\approx \frac{1}{| \text{slope of demand curve} |} \frac{p}{q}
\]
Total Revenue (TR) = \( pq \)

Marginal Revenue (MR) = Change in total revenue per unit of change in output

\[ \frac{\Delta TR}{\Delta q} \]

Geometrically, MR is the slope of the TR curve.
Suppose seller changes price from \( p_0 \) to \( p_0 + \Delta p \)

(From the demand curve), the quantity sold changes from \( q_0 \) to \( q_0 + \Delta q \)

Note \( \Delta p \) and \( \Delta q \) will have opposite signs.

Total revenue changes from \( p_0q_0 \) to \( (p_0 + \Delta p)(q_0 + \Delta q) \).

\[
\Delta TR = (p_0 + \Delta p)(q_0 + \Delta q) - p_0q_0 \\
= p_0 \Delta q + q_0 \Delta p + \Delta p \Delta q
\]

so that Marginal Revenue

\[
= \frac{\Delta TR}{\Delta q} \\
= \frac{p_0 \Delta q + q_0 \Delta p + \Delta p \Delta q}{\Delta q}
\]
\[ p_0 + \frac{\Delta p}{\Delta q} q_0 + \Delta p \]

\[ \approx p_0 + \frac{\Delta p}{\Delta q} q_0, \text{ if change in price is infinitesimally small} \]

\[ = p_0 + \frac{\Delta p}{\Delta q} p_0 q_0 \]

\[ = p_0[1 + \frac{\Delta p}{\Delta q} p_0 q_0] \]

\[ = p_0[1 + \frac{1}{\Delta q p_0}] \]

\[ = p_0[1 - (\frac{1}{\Delta q p_0})] \]

\[ = p_0[1 - \frac{1}{\epsilon}] \]
Thus,

\[ \text{Marginal Revenue} = \text{price} \left[ 1 - \frac{1}{\text{elasticity of demand}} \right] \]

In a perfectly competitive market with price taking firms, demand curve facing individual firm is horizontal i.e., perfectly elastic \((\epsilon = \infty \text{ at the market price})\) and therefore, \(\text{MR} = \text{price} \) (because \(\frac{1}{\epsilon} = 0\)).

For a firm with market power, demand curve is downward sloping which means demand is less than perfectly elastic and so \(\text{MR} < \text{price} - \) the wedge between price and MR depends on price elasticity of demand.
Recall that price elasticity of demand changes as we move from one point of a demand curve to another.

If demand is elastic (at the current price charged by the firm) i.e., \( \epsilon > 1 \Rightarrow \frac{1}{\epsilon} < 1 \)

\[ \Rightarrow MR = p[1 - \frac{1}{\epsilon}] > 0 \]

\( \Rightarrow \) an increase in quantity sold (or a decrease in price) increases total revenue.

Conversely, if demand is inelastic (at the current price charged by the firm) i.e., \( \epsilon < 1 \Rightarrow \frac{1}{\epsilon} > 1 \)

\[ \Rightarrow MR = p[1 - \frac{1}{\epsilon}] < 0 \]

\( \Rightarrow \) an increase in quantity sold (or a decrease in price) decreases total revenue.

[Total revenue is at a maximum when \( MR = p[1 - \frac{1}{\epsilon}] = 0 \) i.e., at a point on the demand curve where elasticity of demand = 1.]
Equation of a simple linear demand curve:

\[ q = \alpha - p \]

where \( \alpha \) is a strictly positive constant.

The inverse demand (price as a function of quantity):

\[ p = \alpha - q \]

For the rest of this course, we will work with this simple demand curve.

\( \alpha \): intercept of the demand curve on both axes.

Slope of the demand curve (absolute value) = 1.
Elasticity of demand at any price-quantity pair \((p,q)\) is given by:

\[
\epsilon = \frac{1}{|\text{slope of demand curve}|} \frac{p}{q} = \frac{p}{q} \quad \text{in terms of price}
\]
\[
\epsilon = \frac{\alpha - q}{q} \quad \text{in terms of quantity sold}.
\]

So at \(p = \alpha, q = 0\), \(\epsilon = \infty\).

At \(p = 0, q = \alpha\), \(\epsilon = 0\).

At \(p = \frac{\alpha}{2}, q = \frac{\alpha}{2}\), \(\epsilon = 1 \Rightarrow\) total revenue is maximized at the price-quantity par corresponding to the midpoint of the demand curve. Demand is elastic at higher prices and inelastic at lower prices.
For a monopolist selling in this market,

\[ TR = pq \]
\[ = (\alpha - q)q \]
\[ = \alpha q - q^2 \]
MR = \frac{\Delta TR}{\Delta q} \text{ is the slope of the TR curve.}

General rule for finding slope of a quadratic function:

For a function

\[ y = A + Bx + Cx^2, \text{ where } A, B, C \text{ are constants} \]

the slope is given by

\[ B + 2Cx \]

Using this rule on the function

\[ TR = \alpha q - q^2 \]

we have

\[ MR = \alpha - 2q \]

So, MR = 0 (total revenue is maximized) when \( q = \frac{\alpha}{2} \).
Monopolist’s profit = Total Revenue - Cost of Production.

Cost of Production:

Cost function: $C(q)$.

Average Cost (AC): $\frac{C(q)}{q}$

Marginal Cost (MC): Change in (total) cost of production per unit of change in output.

$$MC = \frac{\Delta C(q)}{\Delta q}$$
Returns to scale: If all inputs are changed by a certain proportion, is the proportion of change in output

- higher? (Increasing returns to scale or IRS)

- lower? (Decreasing returns to scale or DRS)

- exactly same? (Constant returns to scale or CRS)
IRS ⇒ $AC$ declines with output ⇒ $AC$ curve is downward sloping, $MC < AC$

DRS ⇒ $AC$ curve is upward sloping, $MC > AC$

CRS ⇒ $AC$ curve is horizontal, $AC = MC = \text{constant } c$
for all units of output [$C(q) = cq$]
Let $TR(q)$ denote total revenue when $q$ units are sold.

Let $\Pi(q)$ denote profit when $q$ units are produced & sold

$$\Pi(q) = TR(q) - C(q)$$
What is the marginal effect of a change in quantity produced $\triangle q$ on the profit?

Marginal profit: Change in profit per unit of change in output $= \frac{\Delta \Pi(q)}{\Delta q}$.

If $\frac{\Delta \Pi(q)}{\Delta q} > 0$, then firm can increase profit by increasing output.

If $\frac{\Delta \Pi(q)}{\Delta q} < 0$, then firm can increase profit by reducing output.

So, at a **profit-maximizing level of output** it must be the case that marginal profit is zero:

$$\frac{\Delta \Pi(q)}{\Delta q} = 0$$

Since, $\Pi(q) = TR(q) - C(q)$,

$$\Delta \Pi(q) = \Delta TR(q) - \Delta C(q),$$
Therefore, at the profit maximizing level of output

\[ \frac{\Delta TR(q)}{\Delta q} - \frac{\Delta C(q)}{\Delta q} = 0 \]

i.e.,

\[ MR = MC \]
We know that

\[ MR = p[1 - \frac{1}{\epsilon}] \]

Therefore, at the profit maximizing quantity-price combination for a monopolist it must be true that

\[ p[1 - \frac{1}{\epsilon}] = MC \]

which can be re-written as

\[ \frac{p - MC}{p} = \frac{1}{\epsilon} \]

\[ L = \frac{p - MC}{p} : \text{mark-up of price above MC.} \]

\( L \) is called the Lerner index of market power.

In a perfectly competitive market, price = MC so that \( L = 0 \).

Greater the proportional mark-up of price above MC, more the indication of market power.
Above condition indicates:

\[ L = \frac{1}{\epsilon} \]

*Extent of monopoly power is inversely related to the elasticity of demand.*

Lower the elasticity of demand, greater the deviation of monopoly price from MC (and greater the deviation of the market outcome from an ideal world of perfect competition).
Welfare Loss Due to Monopoly:

Recall from previous micro classes:

Socially optimal output (say, $q^S$) is given by the point where the MC curve intersects the market demand curve.

The demand price for any quantity indicates the amount society is willing to pay for each extra unit of output.

MC curve tells us what it costs society to produce an extra unit of output (assume: no externalities).

If the total output produced in society is such that $MC < \text{demand price}$ (for that level of output), then its worthwhile for society to produce more (marginal willingness to pay > MC).

If the total output produced in society is such that $MC > \text{demand price}$ (for that level of output), then society is better off reducing production (the happiness foregone
as measured by the marginal willingness to pay < MC saved by cutting output).

Therefore, socially optimal solution

\[ MC \text{ at } q^S = \text{ Demand price at } q^S \]
Area under demand curve indicates the gross surplus earned by society by consuming a certain amount of output.

Area under MC indicates the total variable cost of production.

Net surplus to society is the difference between these two

\[ = \text{Producers Surplus} + \text{Consumer Surplus}. \]

Net surplus is maximized at \( q^S \).
Under perfect competition, \( p = MC \) and so total output produced in a market is exactly equal to \( q^S \).

Under monopoly, total output \( q^m \) is such that price > MC and so:

- \( q^m < q^S \) (monopoly output is too small, price charged too high)

- net social surplus is less than optimal.

Difference between net social surplus at \( q^m \) and \( q^S \) is called the deadweight loss of monopoly.
Example:

Demand: \( q = 10 - p \) (linear demand)

Inverse demand: \( p = 10 - q \)

Production Cost: \( C(q) = 2q \) (CRS)

Monopoly outcome:

\[
TR(q) = (10 - q)q = 10q - q^2
\]

\[
MR = 10 - 2q
\]

\[
MC = 2
\]
Profit maximizing output $q^m$:

\[
MR = MC \Rightarrow 10 - 2q^m = 2 \\
\Rightarrow q^m = 4
\]

Monopoly price $p^m$:

\[
p^m = 10 - q^m = 6
\]

Monopoly profit:

\[
p^m q^m - C(q^m) = 24 - 8 = 16
\]

What would be the socially optimal level of output $q^S$ in this market:

Intersection of demand and MC curves:

\[
10 - q^S = 2 \Rightarrow q^S = 8
\]

Deadweight loss of monopoly (DWL):
\[ DWL = \frac{1}{2}(q^S - q^m)(p^m - 2) = 8 \]

Welfare loss due to monopoly: compounded by rent seeking behavior.

Firms waste resources in order to acquire and hold on to monopoly power.
Positive side:

* Monopoly power is a way for the market to reward technological innovation.

Current monopoly profit compensates firms for previous investment.

Joseph Schumpeter: "creative destruction"

New technological innovators wipe out current monopolists and create new monopoly power.

Does good to society.

* Monopoly power reflects enterprise, innovation, technological progress.

* Monopoly power shifts from one technological leader to another.

So even if monopoly power exists, it should not call for intervention.
Thrust of public policy is to oppose:

* long term monopoly power that is abused (just having a monopoly position is not *per se* illegal)

* anti-competitive actions that create monopoly power (*collusion, entry barriers, predation*).

* encourage competition in markets as a way of resolving monopoly power.
In the US, antitrust law.

Sherman Act of 1890:

"Every person who shall monopolize, or attempt to monop-olize, or combine and conspire with any other person or persons, to monopolize any part of the trade or commerce among several States, or with foreign nations, shall be deemed guilty of a felony."

In Europe, Treaty of Rome.
Pure monopoly: rare except in the case of natural monopolies (utilities).

[De Beers in the diamond market].
Natural monopoly: when the technology is characterized by increasing returns to scale (scale economies)

⇒ $AC$ is downward sloping.

For example, constant MC and large fixed cost.

$$C(q) = F + cq$$

$$MC = c, \quad AC = \frac{F}{q} + c$$

Socially efficient to concentrate production in one firm as it minimizes per unit production cost.

[Recall: with IRS, perfect competition breaks down.]
Of course, having a monopoly causes social welfare loss as a monopolist under-produces relative to what is socially efficient.

So, while natural monopolies are allowed to be monopolies, they are subject to regulation.
Initially, most utilities were regulated monopolies.

Significant deregulation in recent years - more competition through:

* regular bidding for the right to be a natural monopolist (auctions)

* allowing several firms to compete in "services" associated with the utility

(for example, all telephone lines may be owned by one firm, but multiple telephone service providers can coexist & compete - paying a fee to the owner of the lines).
More common form of monopoly power (other than natural monopolies):

Dominant Firm:

Markets with one large firm (dominant firm) with large market share & many small firms (competitive fringe).

Dominant firm has cost advantage, large production capacity, adjusts prices slowly - price leader.

Fringe firms have very small capacity, can adjust prices quickly - price followers (charge price at or just below the dominant firm’s price).

Mainframe computers in 60s and 70s: IBM

Photo films: Kodak

Long distance telecom in late 80s: AT&T.

Operating systems: Microsoft.
Suppose that the total production capacity of all fringe firms is $K$.

Then, for any price $p$ charged by the dominant firm, the quantity sold by it is

$$D(p) - K$$

This is called the residual demand.

The optimal price charged by the dominant firm is the same as that charged by a monopolist who faces the residual demand curve (i.e., equate $MC$ to the $MR$ derived from the residual demand curve).
Regulation:

Consider a natural monopoly where the cost function is given by

\[ C(q) = F + cq \]

\( F \) is not sunk.

Here,

\[ MC = c. \]
Socially efficient output $q^S$ is the quantity such that

\[ \text{demand price} = c. \]

Unregulated monopoly output & price $q^m, p^m$:

\[ MR = c \]

Verify that

\[ q^m < q^S, p^m > c \]
Price-cap regulation: price ceiling at $p^S = c$.

(Marginal cost pricing)

If monopolist produces under this regulation (for example if $F$ is sunk), then he just charges the ceiling price $c$ and produces output $q^S$.

As $F$ is not sunk, then monopolist will prefer not to produce under this regulation as his $AC$ of production $> c$. 
One option:

Couple MC-price regulation with a subsidy so that monopolist breaks even after he produces $q^S$ at regulated price $c$. 

Problem with subsidy:

* Must be paid for with taxes that cause distortions (or welfare loss) in other parts of the economy.

* Regulatory capture: monopolist will try to "influence" regulator because the latter has the power to make transfers - wastage of resources.
Alternative: Average cost pricing.

Set regulated price $p^A$ at the point where $AC$ curve cuts the demand curve.

Optimal output is less than what is socially efficient but higher than the unregulated monopoly output.

No need for subsidy: firm just breaks even.

(Ex. In the US: *rate of return* regulation: firm earns "fair rate of return" on capital invested)
Problem: No incentive for cost reduction.

If firm invests in new technology and reduces AC, future regulated price will adjust so that it still earns zero profit & past investment will not be recovered.

One way to address the problem: regulatory lag

A time lag between successive revisions of regulated price.

Firm will have some incentive to reduce cost as it knows it can earn positive profit till the next round of price revision.
More generally, there is a debate between

- fixed price cap regulation (where price cap is fixed for a long period): "high-power incentive mechanism".

- flexible price "rate of return regulation" : "low-power incentive mechanism".

While price-cap regulation of the "high power" kind gives incentive for cost reduction:

* no incentive for improving quality or service (msy reduce qua.

* Information problems - how to set the price cap (cost information is private to firms).