Department of Industrial and Management Engineering
Indian Institute of Technology Kanpur

Training Programme on
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Economics of Power Markets

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Typical Characteristics of Infrastructure/Power Sector

- Technical characteristics
- Economic characteristics
- Socio-economic and organizational characteristics

Technical characteristics

- Input into production
- Technical indivisibity (lumpiness of investment)
- Immobile
- Long life
- Assets not widely traded
- Exclusion could be technically difficult

Economic characteristics

- Reduction of transaction costs
- <u>Sub-additive</u> cost function i.e. there are conditions for <u>natural monopoly</u>
- High sunk costs
- Network externalities
- Little rivalry in consumption

Socio-economic and organizational characteristics

- Necessity of centralized planning and coordination
- Traditionally publicly owned but increasing private-public cooperation
- Sometimes considered citizen right (State should assure a minimum supply)

Infrastructure/Electricity Provision & Need for Economic Regulation

- In in historic times, Kings built bridges, canals etc.!
- In modern times, ownership and operation of infrastructure is undertaken by the governments. While Policy/Regulation, Ownership and Operation was embedded with government, role of regulation was often ignored.

<u>Need for Economic Regulation</u>

- Inadequate and poor quality of services, and poor financial performance under <u>public ownership</u>.
- Private ownership and operation brings in a concern of <u>private monopoly</u> for government as well as consumers .

Economics of Regulation

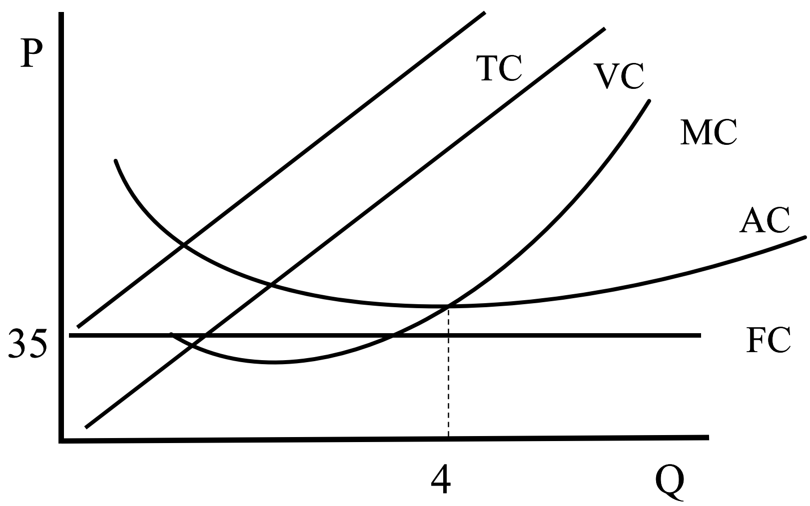
- Perfect Competition - Pricing
- Monopoly - Pricing
- Consumer & Producer Surplus
- Market Failures
- Economic Regulation
- Pricing for Natural Monopoly

Concepts of Perfect Competition and Monopoly

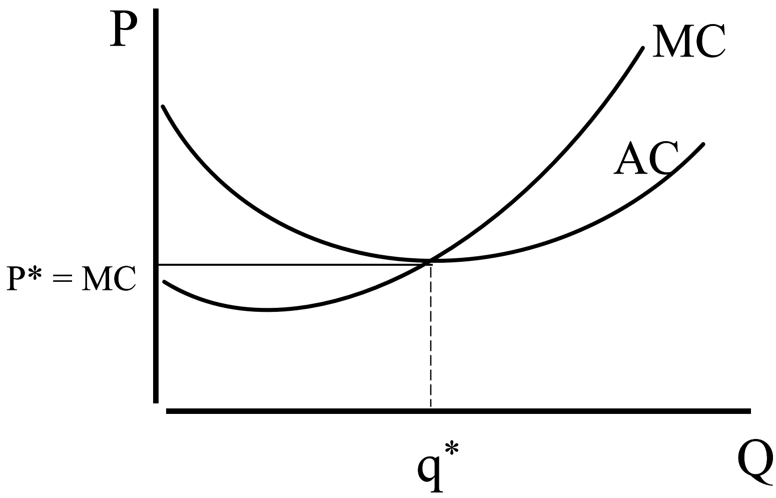
Perfect Competition - Characteristics

- Large number of buyers and sellers, each acting independently
- No buyer or seller is so large to influence the market
- Homogeneous product
- No barriers to entry or exit
- No artificial restraint on prices
- Perfect information
- Profit maximizing firms
- Perfect mobility of factors of production

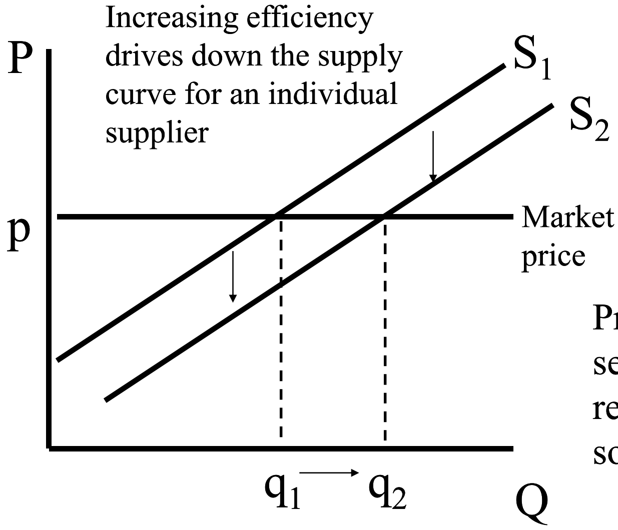
Cost Concepts



Pricing – Perfect Competition Outcome for firm



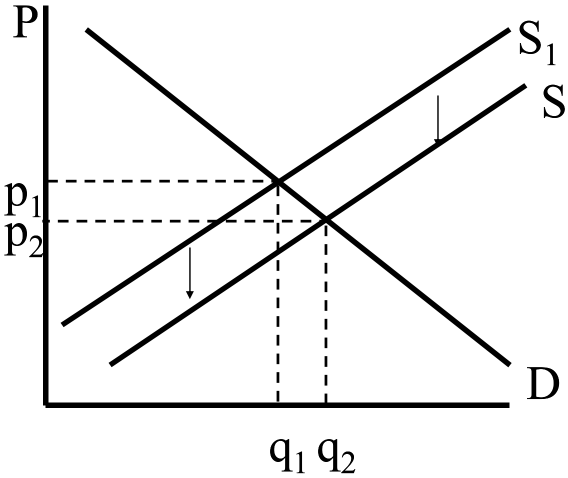
Why companies care about costs



Competitive markets give good incentives for efficiency and innovation

Producer is able to sell more; total revenue increases, so does total profit

Benefits of competition

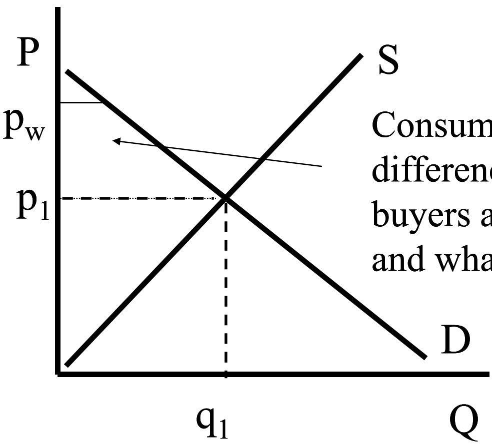


As companies compete with each other, costs are driven down

Consumer benefits:

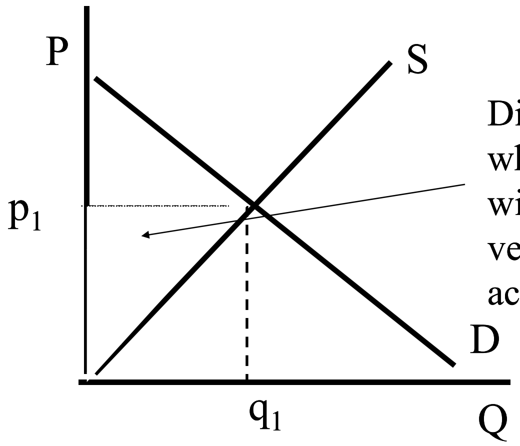
Prices are cut to p_2 and demand rises to q_2 as a result of competition

Consumer surplus



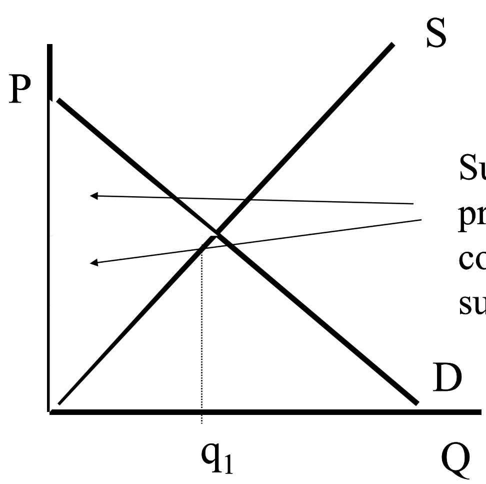
Consumer surplus: the difference between what buyers are willing to pay and what they have to pay

Producer surplus



Difference between what producers are willing to sell at versus what they actually get

Total surplus

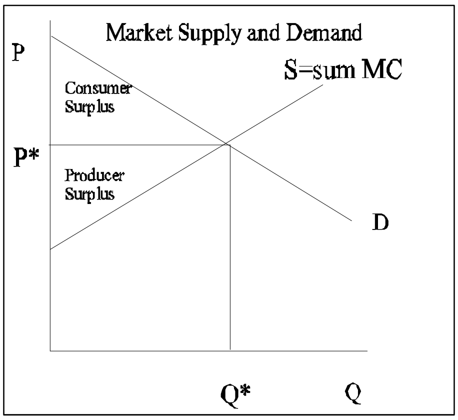


Sum of producer and consumer surpluses

Perfect Competition

- Social Welfare

- Efficiency in Production - incentive to produce at lowest possible cost
- Efficiency in Allocation - right amount of good is produced since MC to produce equals marginal willingness to pay equals price



Concepts of Monopoly

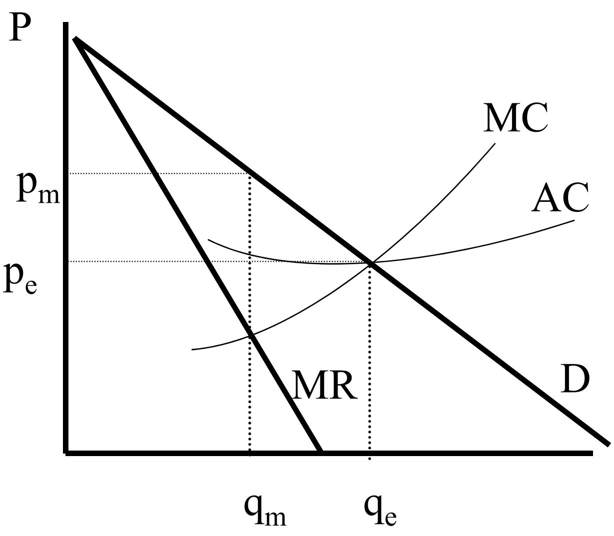
Monopoly

- Single producer (supplier) of products
- Price set by the Monopolist
- Faces no competition because of <u>barriers to entry:</u>
  - high entry costs (investment)
  - legal protection
  - patents, copyrights
  - natural monopoly

Monopoly behaviour

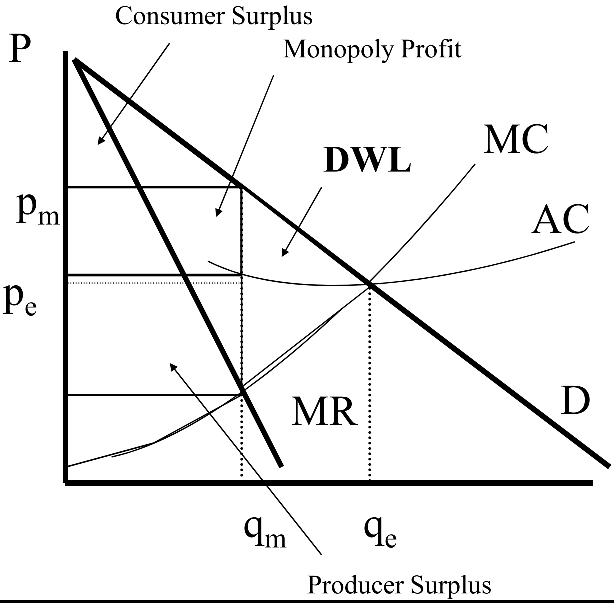
- Goal: <u>maximize profits</u>
- Rational choice: sell less quantity at a higher price (than perfect competition) to maximise profits
- Total surplus (consumer plus producer surplus) is lower than in competitive market case. Dead weight loss.
- X-inefficiency - firm doesn’t work hard to cut costs.

Monopoly: Price Setting



Monopolist sets quantity where profits are greatest, output at which MR=MC

Monopoly: How society looses



Monopolist captures part of consumer surplus.

Consumer surplus lower compared to competitive market case.

"deadweight loss"; social loss as compared to perfect competition

Market Failures

Sometimes markets can fail to operate in beneficial way. Market failures can be so severe as to merit regulation. There are three main classes of market failure:

- Market Power
- Externality
- Information asymmetry

Market Failures (contd.)

- Market Power – Ineffective competition; actual or potential; Monopoly, cartel, monopsony; (special case - Natural Monopoly)
- Externality - behaviour of one firm affects others for reasons other than prices (when firms or people impose costs or benefits on others outside the marketplace)
- Information asymmetry – consumers do not have enough information about the goods that they buy

Natural Monopoly

- Industry cost is minimised by having only firm in the industry.
- Average costs are declining.
- Natural monopolies are likely to exist when there is large fixed-cost component to cost. (fixed costs are large as compared to marginal cost).

Natural Monopoly (contd.)

- In case of natural monopoly – allocative and productive efficiency can not exist together.
- Productive efficiency requires that only one firm produces all output (cost minimised).
- Such firm will fix prices above cost to maximise profits – allocative efficiency is violated.
- For allocative efficiency – a number of firms need to compete to bring prices down to marginal cost (P = MC).

Externality

- Actions of agent A effect the welfare of B.

Negative externality

e.g. environmental pollution, fishing

Positive externality

e.g. beekeeper & farmer

Information Asymmetry

- Infn may not only be imperfect but also asymmetric
- Eg. "Market for lemons"

Why Regulation?

- Regulation – restrictions on decision of economic agents (Firms, consumers)

- Rationale for Regulation
  - Market Power - Natural Monopoly
  - Externality
  - Information asymmetry

  } Market Failure

Types of Regulation

- Antitrust Policy (licensing / certifications) - seeks to protect consumers from anticompetitive behavior through the judicial system (MRTP / Competition Act)
- Direct Regulation or Economic Regulation - controls pricing and/or output due to the belief that the industry is inherently Monopolistic (Power, Telecom etc.). Market power is the main focus of utility regulation.

Types of Regulation (contd.)

- Social Regulation - controls undesirable consequences of firm behavior to obtain various social goods such as clean air and water, safe products and workplaces.
  (Pollution Control Acts, Safety Regulations etc.);
- Technical - licensing requirements, drug regulations, quality certifications like BIS etc., safety in nuclear plants, water flow in hydro plants

Economic Regulation - What can be regulated ?

- Price
- Quantity
- Entry & Exit
- Quality
- Investment
- Access to Resources

Economic Regulation - What can be regulated ? (Contd.)

- Price - power, telecom (partly)
- Quantity - spectrum#, banks branches
- Entry & Exit - telecom, power, banking, insurance
- Quality - telecom, power etc.
- Investment – capacity expansion during license raj
- Access to Resources – mining rights for power (coal), Iron & Steel etc

How to ease Monopolistic Pressure (including regulated natural monopolies)?

- Allow / facilitate entry of more market players
- 'Control/influence' prices / quantity supplied
- Create incentives so that Monopolists emulates a competitive behaviour.

Regulation of Natural Monopoly

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Natural Monopoly – Economic Definitions

- In an industry, where average cost of a single firm that can produce entire output to meet the market demand is lower than in case of presence of more than one firm. (subadditivity of the cost functions).
- An industry that does not 'naturally' attract entrants and who can not survive even in the absence of predatory measures by the incumbent monopolist (sustainability of monopoly).

Economic characteristics of Natural Monopoly

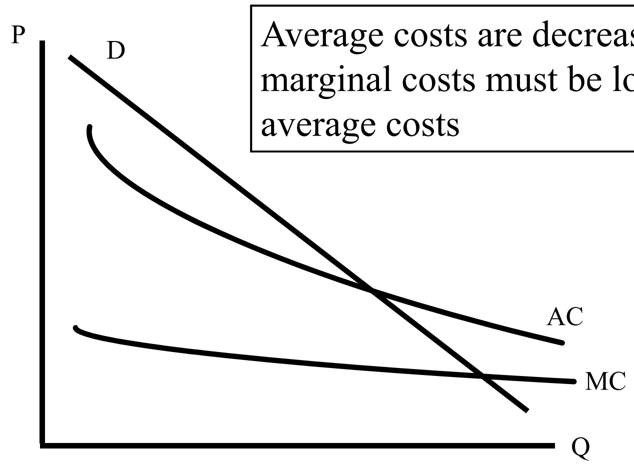
- Production is more efficient by one firm than by many firms
  - average cost of production is falling over the relevant portion of market demand(?)
- pricing at marginal cost results in losses, rendering competition undesirable
- public utility industries (gas, electric, water) characterised by
  - high fixed cost network infrastructure
  - returns to scale

Economic Conditions for Natural Monopoly

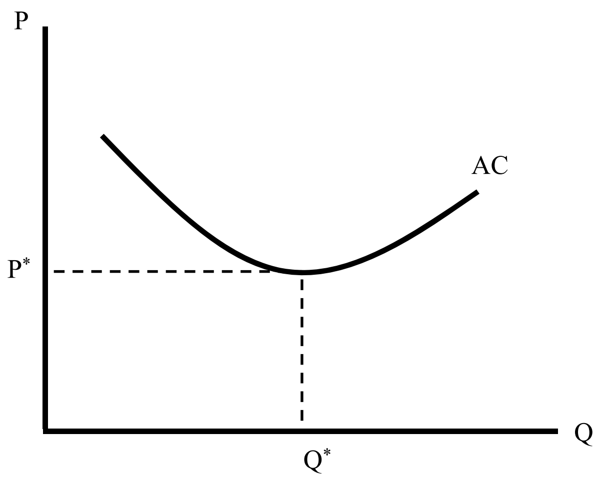
- Falling average and Marginal cost is a sufficient condition
- Presence of sub-additivity is a necessary condition
- Sustainability of monopoly

Natural Monopoly: Cost Characteristics

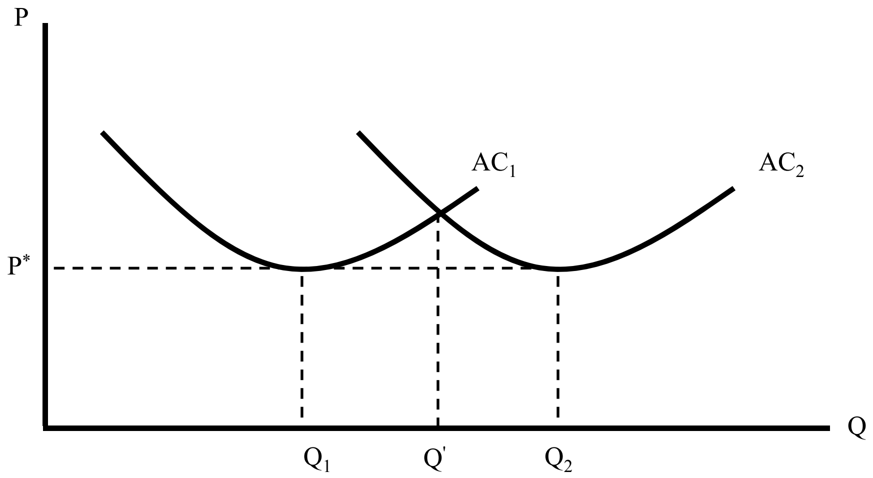
Average costs are decreasing, so marginal costs must be lower than average costs



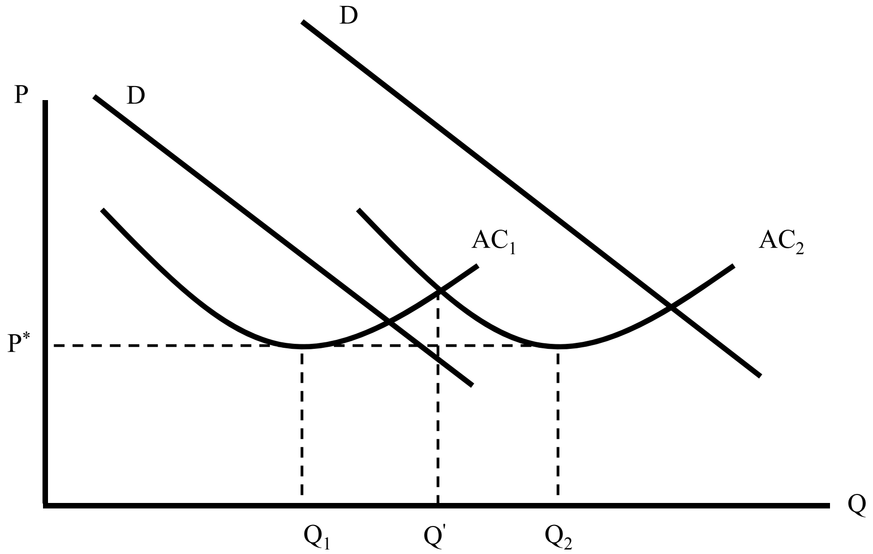
Natural Monopoly: Sub-additivity



Natural Monopoly: Sub-additivity



Natural Monopoly: Sub-additivity



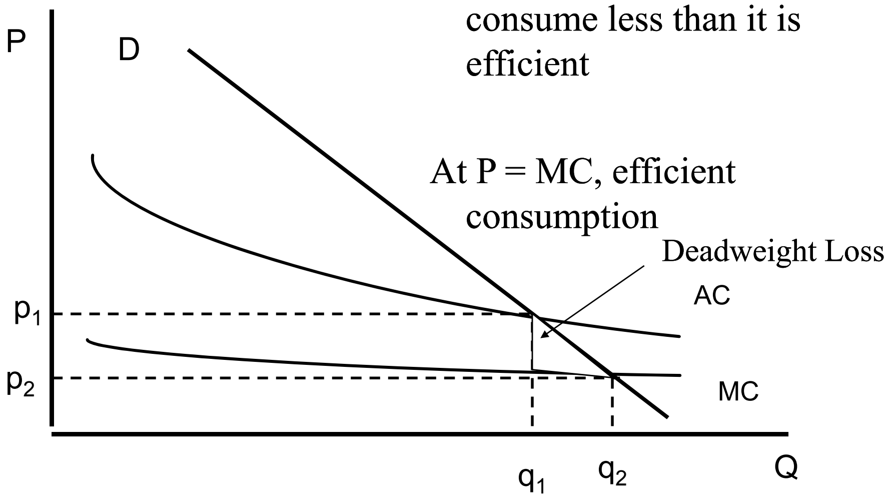
Pricing for Natural Monopoly

- MC Pricing
- AC Pricing
- Non-Linear Pricing

Natural Monopoly: MC Pricing

At P = AC, consumers consume less than it is efficient

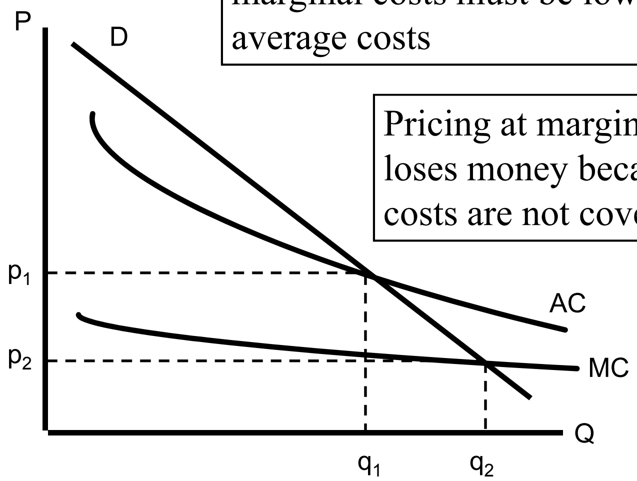
At P = MC, efficient consumption



Natural Monopoly: MC < AC

Average costs are decreasing, so marginal costs must be lower than average costs

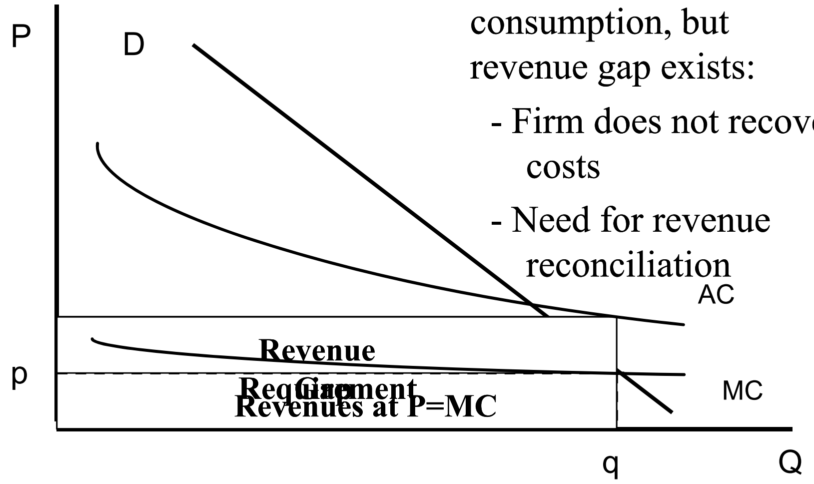
Pricing at marginal cost, firm loses money because average costs are not covered



Natural Monopoly: Revenue Gap

At P = MC, efficient consumption, but revenue gap exists:

- Firm does not recover all costs
- Need for revenue reconciliation



Marginal Cost Pricing

- Outcome has allocative efficiency.
- Weak incentive to reduce costs.
- Firm does not covers costs and makes losses.
- Use tax revenues or direct subsidy to firm to cover revenue shortfall?

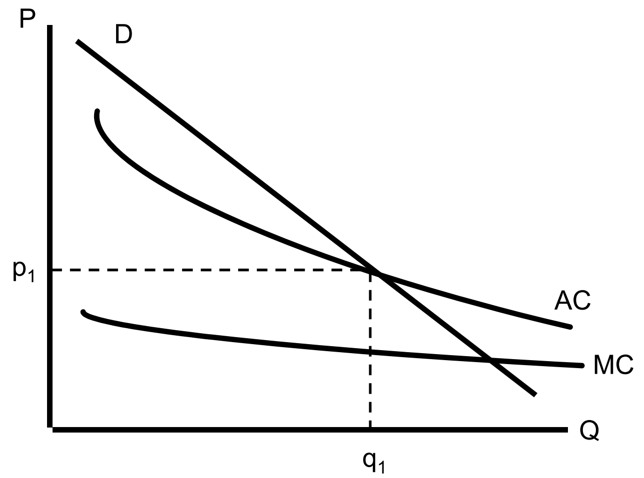
Issues with use of subsidy for bridging revenue gap

- Subsidy for bridging the revenues shortfall
  - Govt. need to raise taxes to fund the subsidy. Taxes are distortionary
  - Reduced incentive for cost reduction since the producer knows that revenue gap would be funded

Average Cost Pricing

- Firm covers costs including opportunity cost of capital.
- Weak incentive to reduce costs since costs re covered.
- Does not require subsidy or distortionary taxes to cover revenue shortfall.

Average Cost Pricing



Average Cost Pricing (Contd.)

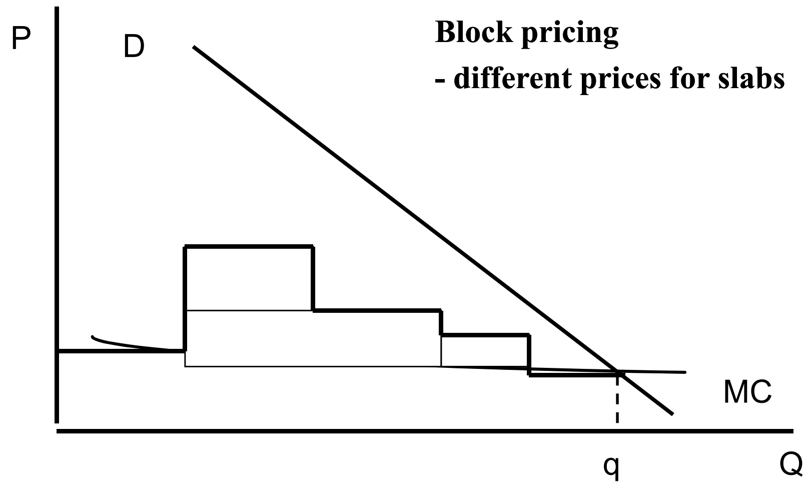
- Firm covers costs and earns economic profits.
- Failure of allocative efficiency. Less quantity and higher price that in MC pricing case (but lower P and higher Q than profit maximisation by the monopoly)
- Weak incentive to reduce costs.

Natural Monopoly: Non-Linear Pricing

- Also called Block Pricing
- Most basic form would be a two-part tariff
  $P = a + b\,Q$
  b is set equal to marginal cost
  a covers revenue shortfall due to MC pricing.

- If Σ a (across all consumers) = revenue shortfall to ensure economic profits, it ensures allocative efficiency and firm earns economic profits. It still lacks incentive to continuously reduce costs.

Natural Monopoly: Declining Block Pricing



Ramsey Pricing

- When it is easy to identify the characteristics of users of a public service, multi-part tariffs -- often called discriminatory prices -- may be useful in achieving efficiency.
- Suppose that price elasticity of distinct groups of users (say, domestic and commercial consumers) is known, and is different. The less elastic the demand, the higher the price that should be charged on efficiency grounds.
- Those with more alternatives, can switch to other services, will reduce demand in response to the higher price. Those with fewer choices would be charged more.
- Charging what the market will bear may not always be considered fair.

Ramsey Pricing (Contd.)

- For multi-product natural monopolist, MC pricing leads to negative profits. If price for each product exceeds MC it can cover this shortfall. By how much?
- Ramsey Pricing Rule

$(P_i - MC_i)/P_i = X/E_i$, $i = 1, 2, \ldots, N$ products,

Where, X - a constant, E_i - own price elasticity of demand

Thank You

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Selected Papers on Power/RE

- "Analysing Efficiency of Electric Distribution Utilities in India: a Data Envelopment Analysis" (with Dilip Kumar Pandey), IAEE International Conference, Stockholm 19-23 June, 2011.
- "Modelling Economic Efficiency of Renewable Energy Policies: A Multi-State Model For India", Accepted for World Renewable Energy Congress, 17-19 Oct. 2011, Bali, Indonesia. (with Sundeep Chowdary).
- "Economics, Regulation and Implementation Strategy for Renewable Energy Certificates in India" in India Infrastructure Report 2010, Oxford Univ. Press.
- "Towards a Competitive Market for Electricity and Consumer Choice in Indian Power Sector", Energy Policy Vol. 38 4196-4208, 2010. (Elsevier)
- "A Market for Renewable Energy Credits in the Indian Power Sector", Renewable and Sustainable Energy Review journal, Elsevier, 2009.
- "Economics of Iran-Pakistan-India Natural Gas Pipeline: Implications for Energy Security in India", Economic and Political Weekly, Vol. XLIII, No. 7 2008.
- "Power Sector Reform in India: Current Issues and Prospects", Energy Policy, Elsevier, Volume 34, Issue 16, November 2006.

Courses, Workshops and Conferences

- Short Term Course "Challenges and Implementation Issues post Electricity Act 2003: Regulatory, Policy & Technical Solutions", 10-14 April, 2004
- International Conference on "Power Market Development in India: Reflections from International Experience", 19-21 April, 2005
- National Workshop on "Project Financing for Energy and Infrastructure Sector", April 19-22, 2007
- 2nd National Workshop on "Project Financing for Energy and Infrastructure Sector", April 24-27, 2008
- Capacity Building Programme for Officers of Electricity Regulatory Commissions, 30th June - 5th July, 2008

Courses, Workshops and Conferences (contd.)

- 2nd Capacity Building Programme for Officers of Electricity Regulatory Commissions, 3-8 August, 2009
- 3rd Capacity Building Programme for Officers of Electricity Regulatory Commissions, 23-28 August, 2010
- Energy Conclave 2010, 8-15 Jan. 2010
- 4th Capacity Building Programme for Officers of Electricity Regulatory Commissions, 18-23 July, 2011
- 5th Capacity Building Programme for Officers of Electricity Regulatory Commissions, 18-23 Oct., 2012
- 6th Capacity Building Programme for Officers of Electricity Regulatory Commissions, 9-15 Feb., 2014

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