



The economics of competitive and opening markets

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What is wrong with electricity markets?

- How to achieve competition?
 - Distribution natural monopoly
 - Transmission natural monopoly-ish
 - Retail -> competition
 - Wholesale -> competition
 - Generation -> competition
- Supply competitive
- Demand -> no flexibility



How natural monopoly entered into discussion?

- Samuel Insull and Chicago Edison
- Natural monopoly
 - Tremendous economies of scale
 - Huge capital investment
- "like railroads"
- In Chicago 18-20 utilities & economies of scale
- One utility per geographic area

Competition based on what?

- Price
 - Electricity price is a reality or a socio-technological construct?
 - Locational marginal price?
- Service quality????
- Different products (green, baseload)
- If there is competition, it will result in differentiated products to gain market share



Perfect competition

- Large number of buyers & sellers (Country specific)
- Perfect information (no lemons) (Market operator)
- No barriers to entry&exit (Regulation)
- Cheap & efficient transport (Transmission)
- But no profits in "Perfectly competitive markets"

Power Market Specific - Missing Money

- Missing money problem: for various reasons prices for energy in these markets may not fully reflect the value of investment in the resources needed to meet customers' expectations for reliable electric service
- money is “missing” from the market can, in turn, impede needed investment
- In competitive equilibrium competition:
 - $\text{Marginal cost} = \text{Marginal price}$.. no CAPEX??
- Can markets be competitive with capacity payments?



3 different approaches

- Market failure framework
- Austrian framework
- Asset based & systems framework

Approach 1

THE MARKET FAILURE FRAMEWORK

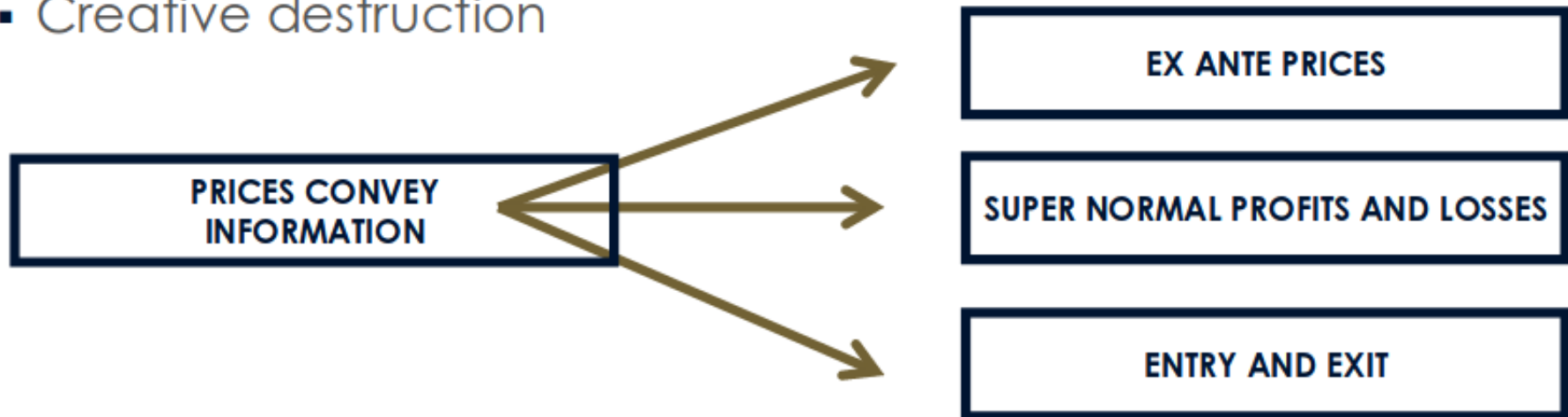
- The perfectly competitive market ideal
- Fundamental theories of welfare economics
- Pareto optimality and general equilibrium



Approach 2

THE AUSTRIAN FRAMEWORK

- Competition is dead in perfect markets
- Trial and error
- Profits create incentives
- Creative destruction



Approach 3

ASSET BASED & SYSTEMS FRAMEWORKS

- Core infrastructure systems
- Assets-in-perpetuity
- Capital maintenance
- Non-marginal analysis

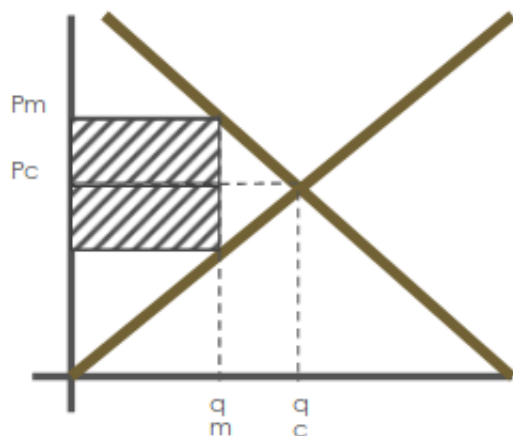
CORE SYSTEM ANALYSIS

SUSTAINABLE ASSET BASES

BALANCE SHEETS & CCA
ACCOUNTING

Monopoly and market power

I: NEOCLASSICAL VIEW (CONVENTIONAL)



II: AUSTRIAN VIEW

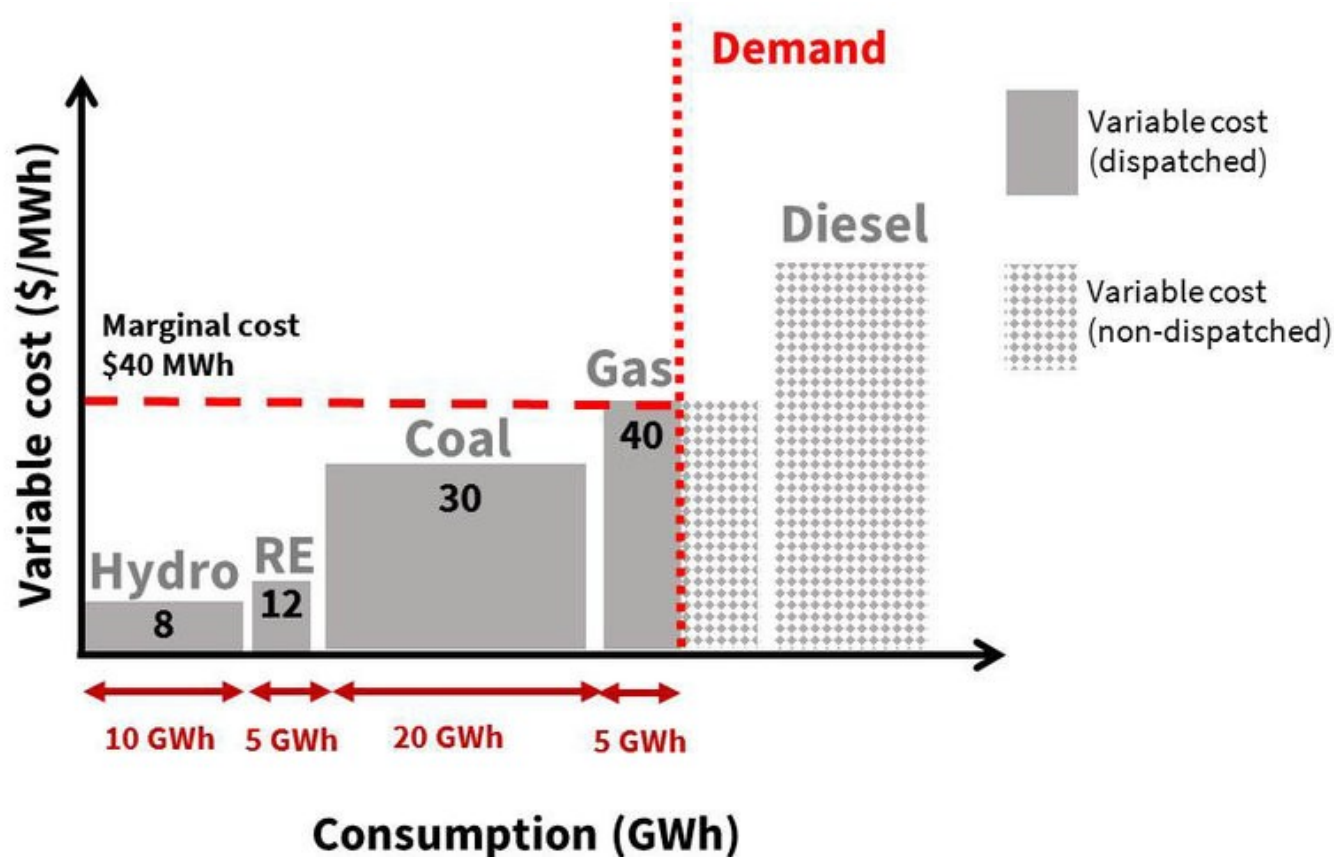
- P_c/q_c not competitive
- Entry & dynamics
- Incentive impacts of profits
- Entrepreneurs and tech change

III: ASSET VIEW

- Sunk fixed costs to asset base
- Operations separate for assets for pricing purposes
- Costs include capital maintenance
- Competitions for CAPEX and OPEX

Basic theory

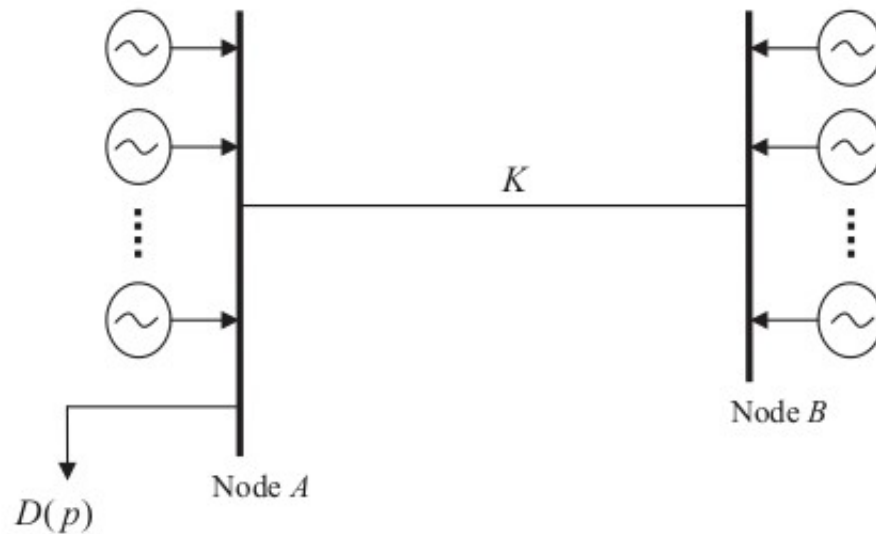
- Two fold – Merit Order & Marginal pricing



Competition with renewables

- FIT -> not competitive
- Tenders -> competitive? Locked – in cost no eff.
- How does the 100 PV panels connected to same node may compete with each other?
- Competition of zero marginal cost resources

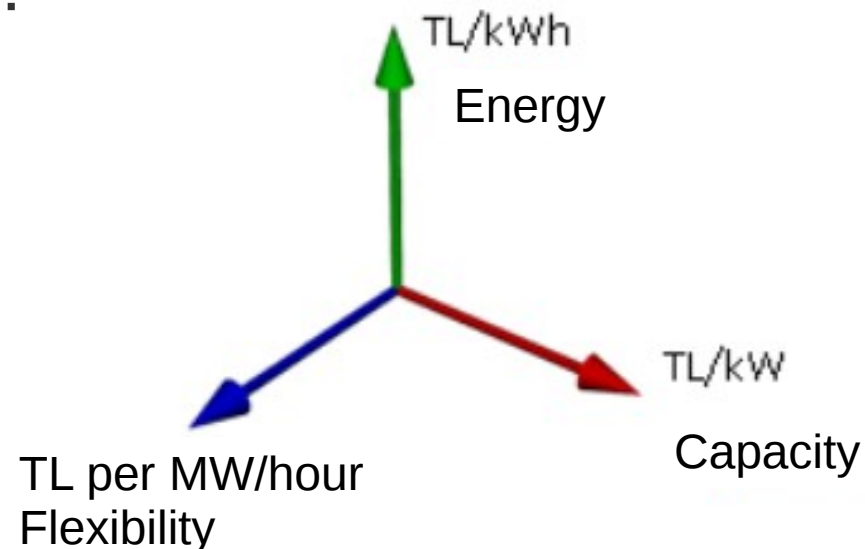
2 node market



- Consumer surplus
- Congestion rents
- Market power

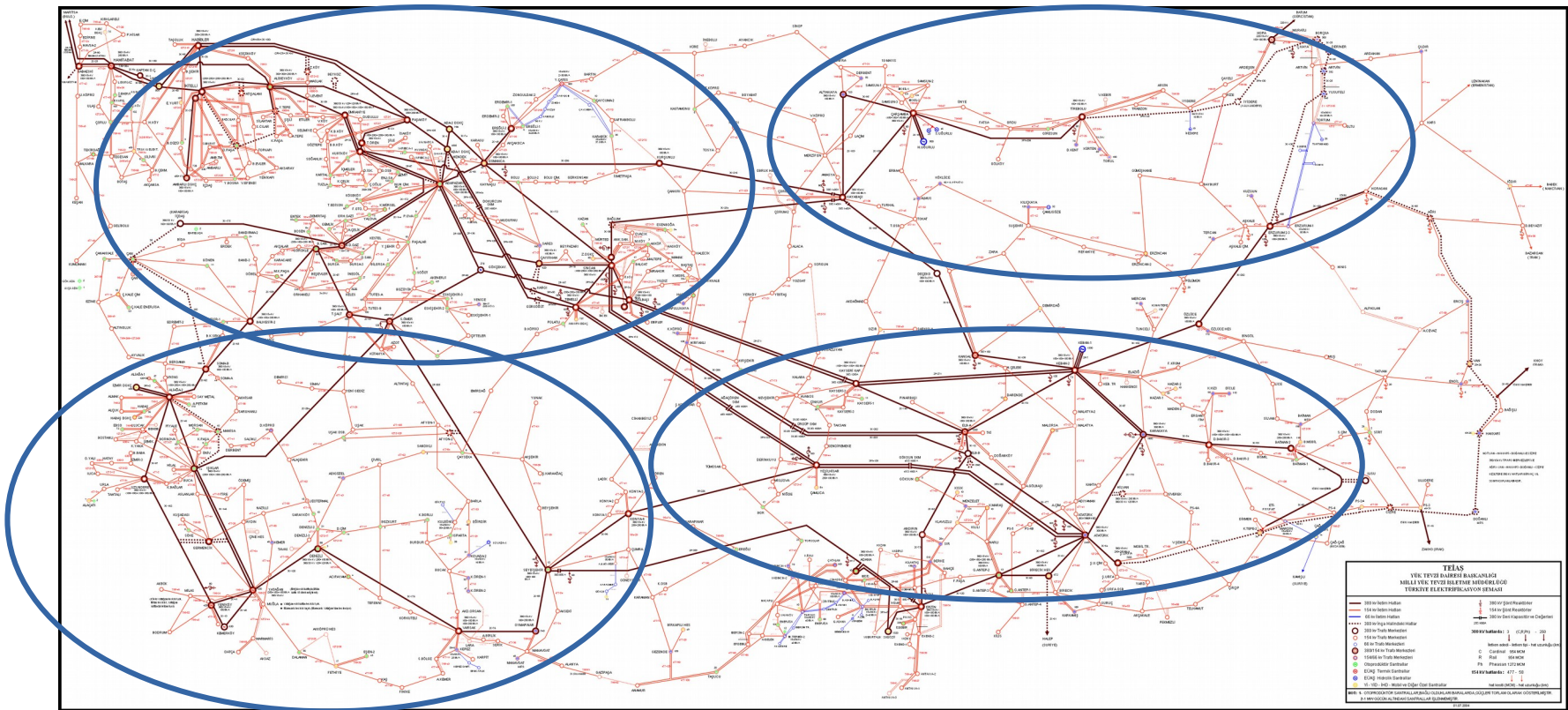
Barriers to competition

- There is
 - CAPEX
 - OPEX
- But revenue is coming from one variable €/kWh
- Does it representative?



100

- A market is in a reality a combination of sub markets due to transmission (eff & cheap transport)





Electricity has

- a locational value
 - No storage
 - No transmission
- Capacity has a value
- Flexibility has a value (with increasing importance)
- Competition based on these values

How to disrupt competition

- Regulator sees one market
 - Gamer sees submarkets (constraints)
- Regulator sees large number of players
 - Gamer see a dominant player's sub market
- Regulator sees perfect information
 - Gamers exchange outage data
- Regulator sees no barriers to entry & exit
 - Everyone know infra build takes years



Real life

- If supply close to demand
 - Lots of opportunities to exploit competition
- If transmission is limited
 - There is a price influencer in some regions
- Capacity withholding harms competition
- Financial products make things complicated
- In coupled markets (nat gas – power)
 - Check both



Technical part economics of competitive markets

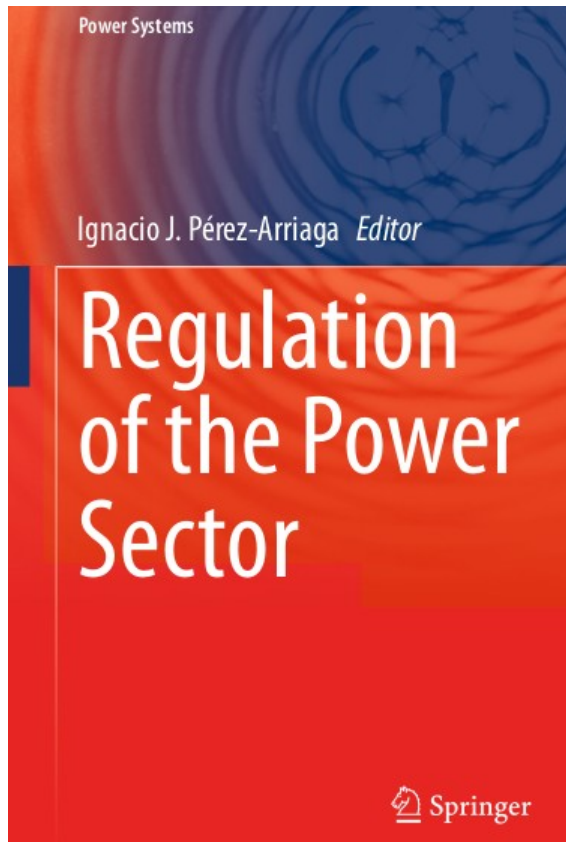
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Reading Material

Chapter 2

Power System Economics

Mariano Ventosa, Pedro Linares and Ignacio J. Pérez-Arriaga



Why the electricity industry underwent profound worldwide in the 1990s is a question that cannot be answered without an understanding of the economic fundamentals.

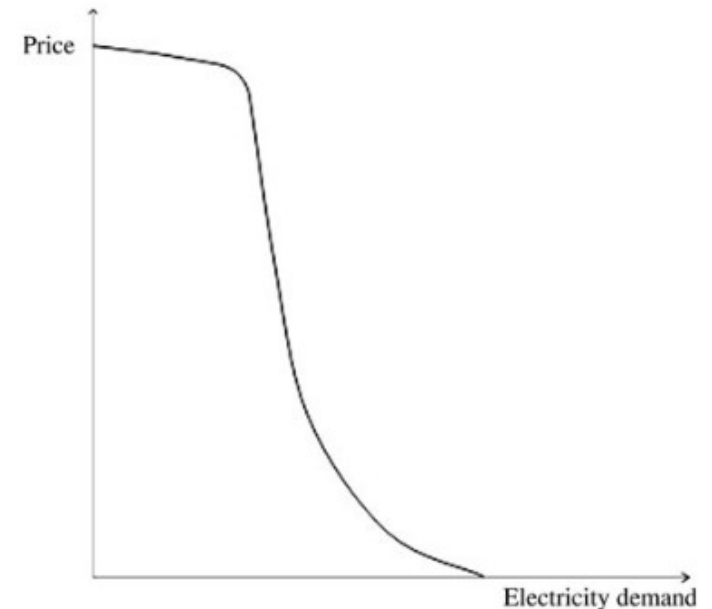
- ▼ 2.1...The Role of Economics in Power Systems
 - 2.1.1 Electricity Demand
 - ▼ 2.1.2 The Costs of Producing Electricity
 - 2.1.2.1 Production Costs
 - 2.1.2.2 Fixed and Variable Costs
 - 2.1.2.3 Average and Marginal Costs
 - 2.1.2.4 Generation Costs
 - 2.1.2.5 Transmission and Distribution Costs
 - 2.1.2.6 Other Costs of Power Systems
 - 2.1.3 Economies of Scale. From Monopolies to Markets
- ▼ 2.2...Market Fundamentals
 - 2.2.1 Consumer Behaviour and the Demand Curve
 - 2.2.2 Producer Behaviour and the Supply Curve
 - 2.2.3 The Law of Supply and Demand
- ▼ 2.3...Perfect Competition
 - 2.3.1 Perfectly Competitive Markets in the Short Term
 - 2.3.2 Economic Efficiency in the Short Term
 - ▼ 2.3.3 The Transition Between the Short-Term and the Long-Term
 - 2.3.3.1 A Simple Example
 - 2.3.3.2 The General Theory
- 2.4...Monopolies
- ▼ 2.5...Market Structure, Concentration and Market Power
 - 2.5.1 Determinants of Market Structure
 - 2.5.2 Contestable Markets
 - 2.5.3 Vertical Integration
 - 2.5.4 Defining, Measuring and Mitigating Market Power
- ▼ 2.6...Oligopoly, Collusion and Strategic Competition
 - 2.6.1 Oligopoly
 - 2.6.2 Non-cooperative Oligopoly Models
 - 2.6.3 Cooperative Models: Collusion and Cartel
 - 2.6.4 Strategic Competition
- 2.7...Market Failures and Externalities
- A.0. Annex A Standard Microeconomic Theory
- References

The role of economics

- Allocation of scarce capital, labour and raw materials to satisfy a range of electricity services
- There is
 - Positive economics (real world)
 - Normative economics (ideal)
 - Affordable, reliable.... But today "welfare maximizing"
- Three elements
 - Demand, supply and allocation (objectives and mechanisms)

Demand

- Time dependent
- Non storable
- Inelastic
- "As a service" rather than "good"
- Different services (utility differs with time, quality and type of use)
 - Willingness to pay & elasticity of demand differs by services
 - Short term elasticities 0.05-0.25 for households
 - 0.1-0.9 for industries



Cost of producing electricity

- Production costs : labour, capital, nat. Resources

$$q = f(L, K, T)$$
$$TC(q) = w \cdot L + r \cdot K + e \cdot T$$

- Some of these costs do not change with level of demand
 - Fixed costs (investment costs)
- The cumulative costs of fuel change with demand level
 - Variable costs
- Externatilies

T is total production cost
 w is the unit labour cost
 L is the amount of labour
 r is the unit capital cost
 K is the amount of capital
 e is the unit cost of natural resources
 T is the amount of natural resources

Time span & Marginal cost

$$TC = VC + FC$$

TC is total cost, VC is variable cost and FC is fixed cost.

- Short term

- Several minutes to 1 year

$$AC = \frac{TC}{q} = \frac{VC}{q} + \frac{FC}{q} = AVC + AFC$$

- Long term

- 5,10,20 years

$$MC = \frac{\partial(TC)}{\partial q}$$

- Marginal cost is equal to change in total cost when output rises or declines by one unit. So it is derivative of variable costs
- Long run marginal costs derivative of total costs
 - In the long term marginal costs are flat



Generation costs

- Investment costs
 - Construction requires capital, labour, materials
 - exchange unit(€) per kW
- Operation and maintenance (O&M)
 - Personnel overheads
 - Turbine maintenance depends on
 - Operating hours
 - Start-ups
- Fuel costs (neither necessarily constant nor linear with output)

Generation Costs

Plant type	Capacity factor (%)	U.S. Average levelised costs (2010 \$/megawatthour) for plants entering service in 2017				
		Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system levelised cost
<i>Dispatchable technologies</i>						
Conventional coal	85	64.9	4.0	27.5	1.2	97.7
Advanced coal	85	74.1	6.6	29.1	1.2	110.9
Advanced coal with CCS	85	91.8	9.3	36.4	1.2	138.8
Natural gas-fired						
Conventional combined cycle	87	17.2	1.9	45.8	1.2	66.1
Advanced combined cycle	87	17.5	1.9	42.4	1.2	63.1
Advanced CC with CCS	87	34.3	4.0	50.6	1.2	90.1
Conventional Combustion Turbine	30	45.3	2.7	76.4	3.6	127.9
Advanced combustion turbine	30	31.0	2.6	64.7	3.6	101.8
Advanced nuclear	90	87.5	11.3	11.6	1.1	111.4
Geothermal	91	75.1	11.9	9.6	1.5	98.2
Biomass	83	56.0	13.8	44.3	1.3	115.4
<i>Non-dispatchable technologies</i>						
Wind	33	82.5	9.8	0.0	3.8	96.0
Solar PV ^a	25	140.7	7.7	0.0	4.3	152.7
Solar Thermal	20	195.6	40.1	0.0	6.3	242.0
Hydro ^b	53	76.9	4.0	6.0	2.1	88.9

^a Costs are expressed in terms of net AC power available to the grid for the installed capacity

^b Hydro is assumed to have seasonal storage so that it can be dispatched within a season, but overall operation is limited by resources available by site and season



Generation

- Baseload (generally)
 - Low variable costs
- Peak
 - Low investment & high variable costs (OC NG)
- Mid-range or intermediate
- Non dispatchables (Solar, wind)
- Optimal size (500-1500 MW)

Transmission & Distribution

- Ohmic losses
- Transmission (1-2%)
- Distribution (+10%)
- Transmission line investment costs

Voltage (kV)	Number of circuits	Power rating MVA	Cost k€/km	Cost per unit k€/km/MVA
230	Single circuit	400	410	1025
230	Double circuit	800	660	825
345	Single circuit	750	580	773
345	Double circuit	1500	930	620
500	Single circuit	1500	830	553
500	Double circuit	3000	1325	433

Source Western renewable energy zone (WREZ) initiative [14]

Other costs of power system

- Compensations for regulatory changes
 - Competition transition or stranded costs
- Subsidies for domestic non competitive fuels
- Support for renewable
- Energy efficiency, savings, demand management
- Energy related R&D
- Smart grid
- Regulatory agency & power exchange costs



Economies of scale

- Strong economies of scale in power industry
 - Average production cost decrease with output volume
- Exhaustion of economies of scale key to competitive markets

Markets

- Type of markets

Demand → Supply ↓	Many buyers	Few buyers	One buyer
One seller	Monopoly	Partial monopoly	Bilateral monopoly
Few sellers	Oligopoly	Bilateral oligopoly	Partial monopsony
Many sellers	Perfect competition	Oligopsony	Monopsony

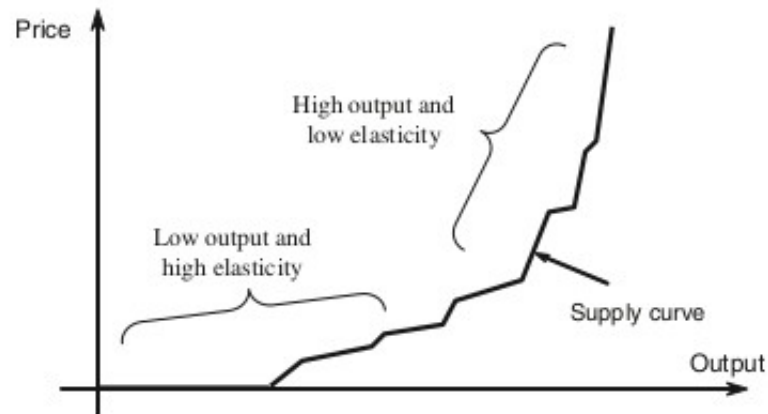
- Microeconomics: "what forces determine the amount of a given good/service is produced and the price it is bought & sold"

Consumer behaviour

- Marginal utility
- $MU < p$
 - Refrain
- $MU > p$
 - Consume
- Demand curve is vertical, completely inelastic
- Price info transmission is mostly broken
 - Hourly price -> monthly bill
- Price cap: Value of lost load

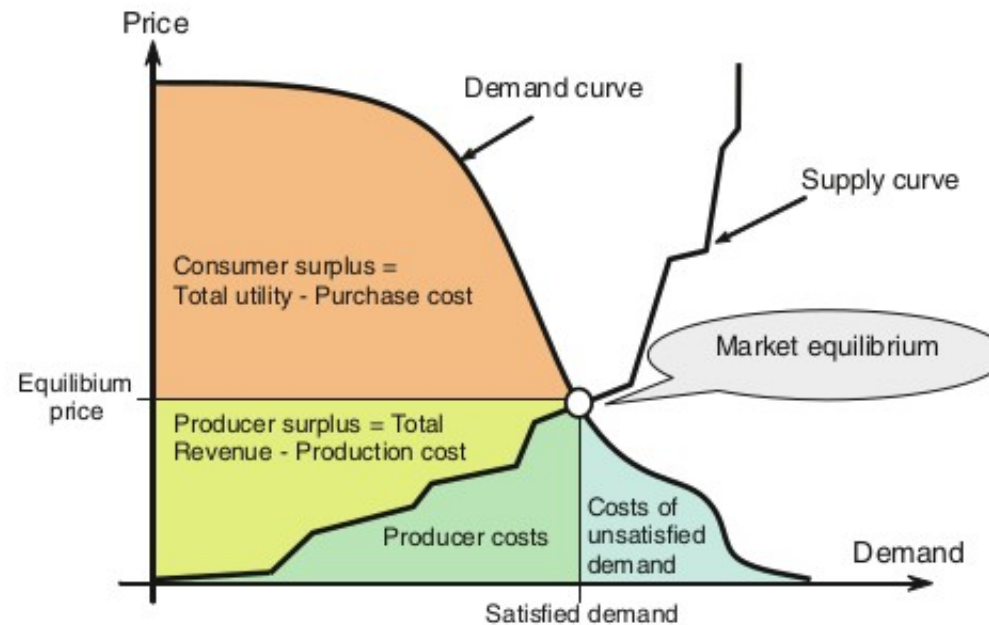
Producer behaviour

- Highest possible profit
- Compares cost and revenue
- Typical electricity supply curve in the short term

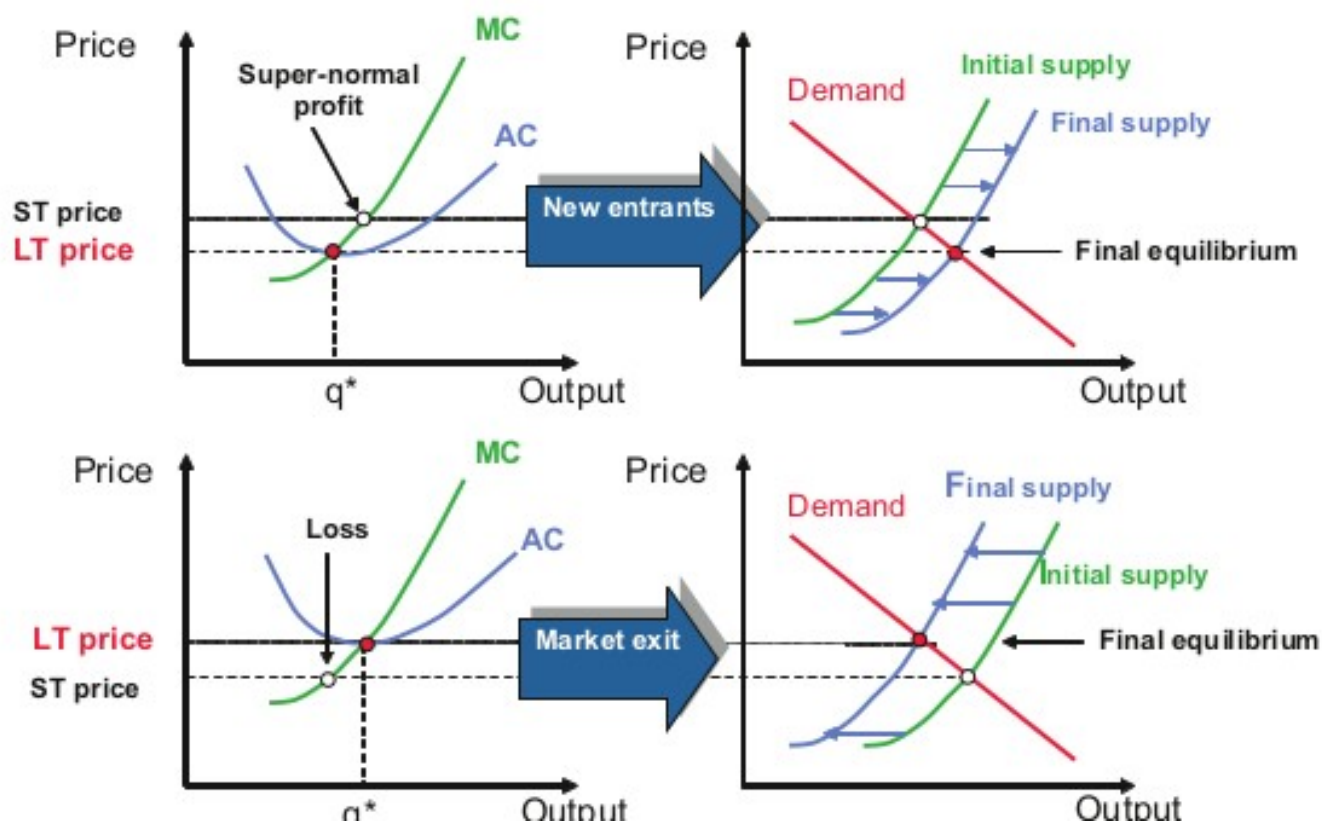


Supply and Demand

- Equilibrium between electricity supply and demand in short term



Market entry and exit

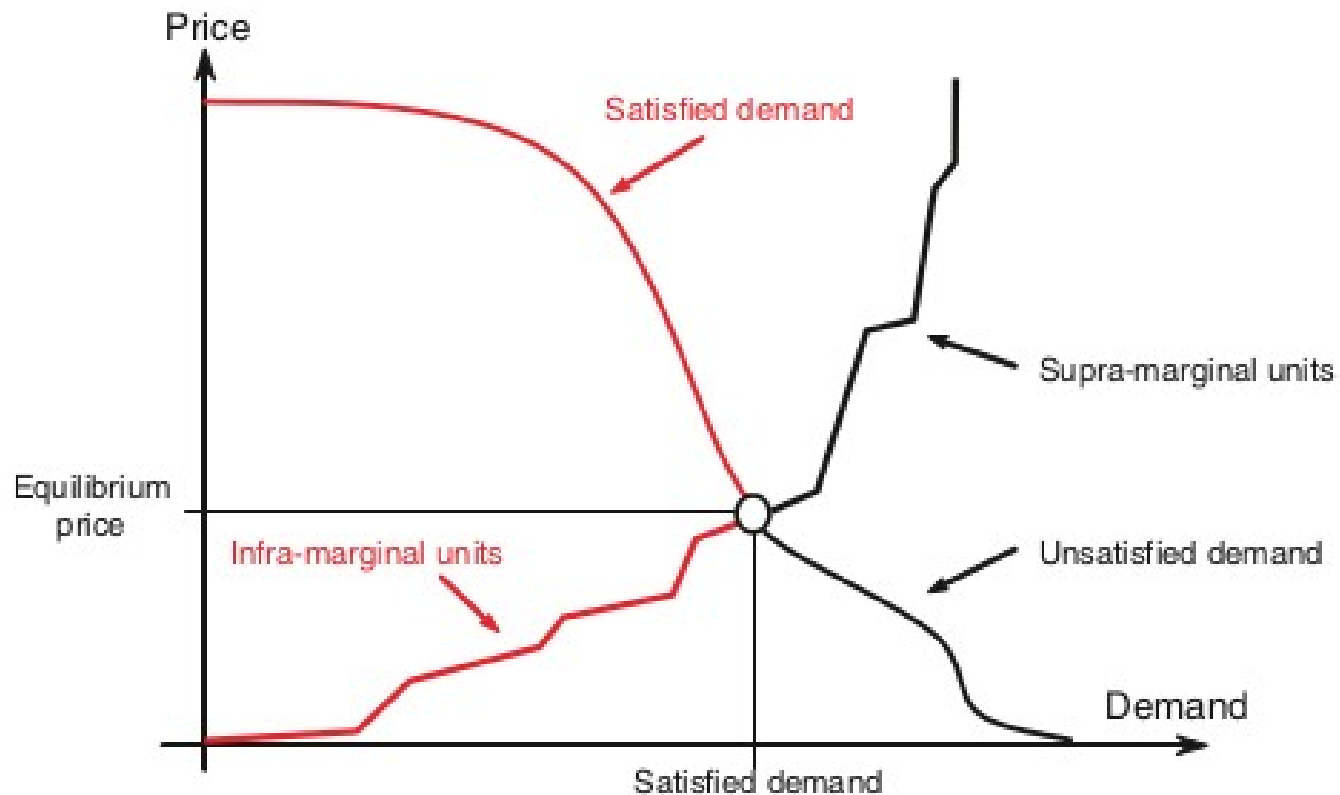




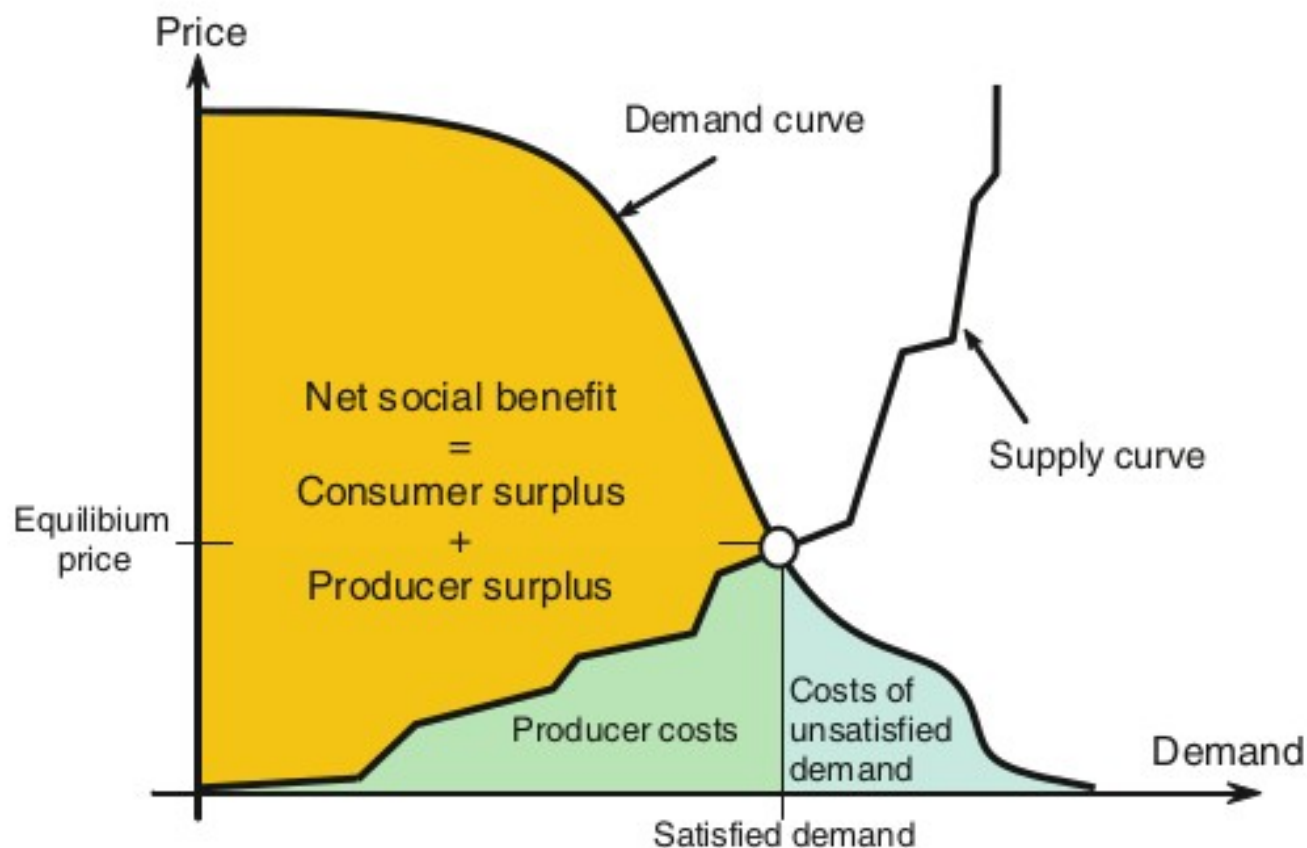
Perfect competition

- Difficult to sustain
- Exist when no producer exerts individual influence
 - When all suppliers are "price takers"
- Two sub conditions
 - Power system is large enough, no significant economies of scale
 - the ownership of the plants of each technology is well distributed among the several competing firms
- All actors have perfect or full information on the going price

Short term supply demand



Economic efficiency in ST



- Welfare ~ Net social benefit
- When each cons & prod act independently



Different models

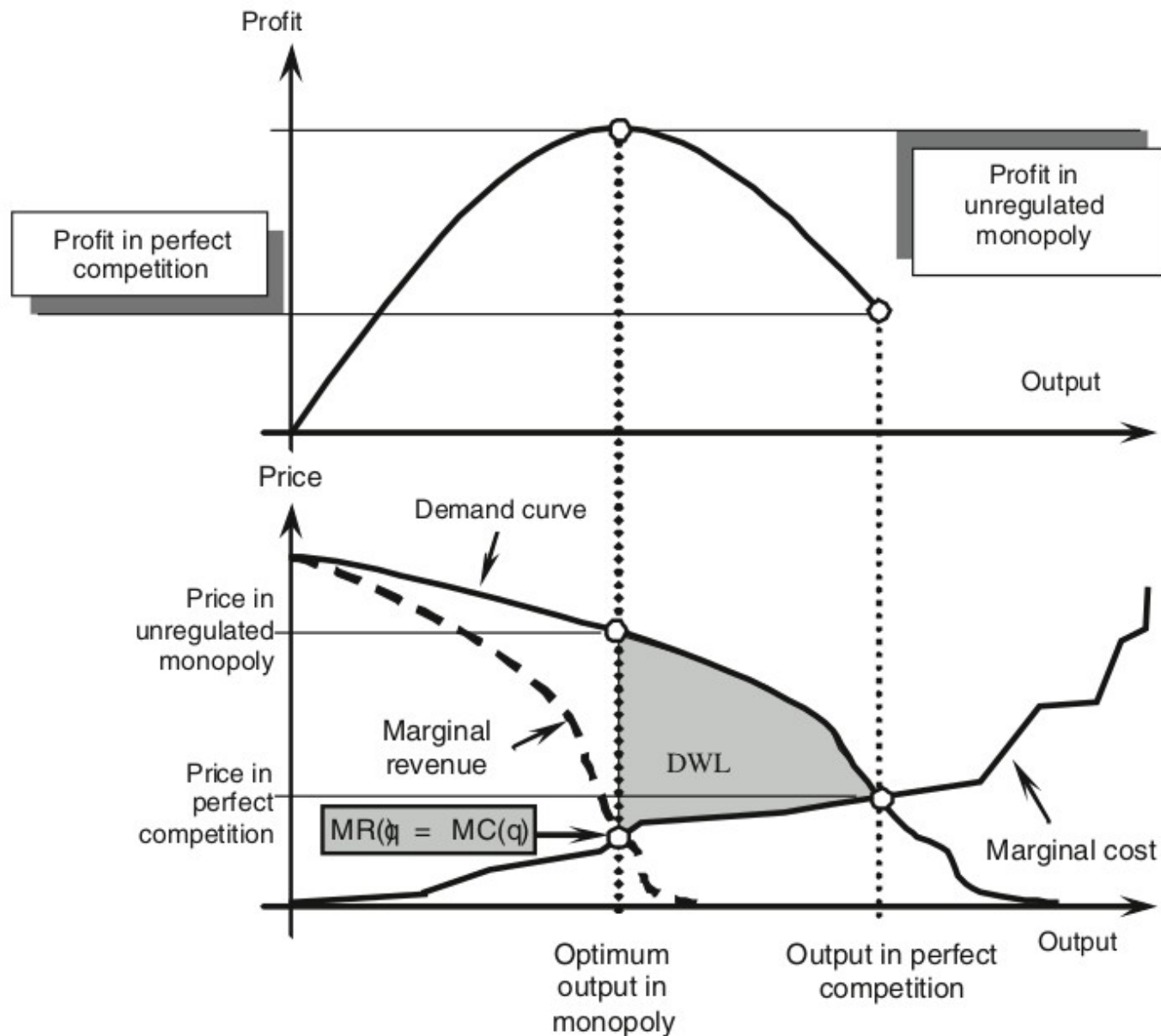
- Centralised planner
- Monopoly
- Non regulated monopoly



Monopolies

- Regulated monopolies were the preferred method
- Efficiency -> single company, all services
- A monopolistic electric company
 - Exclusive control on production and price
- Without regulation
 - Will reduce output, raise revenue
- Unregulated monopolies should not exist

Monopolistic Firm



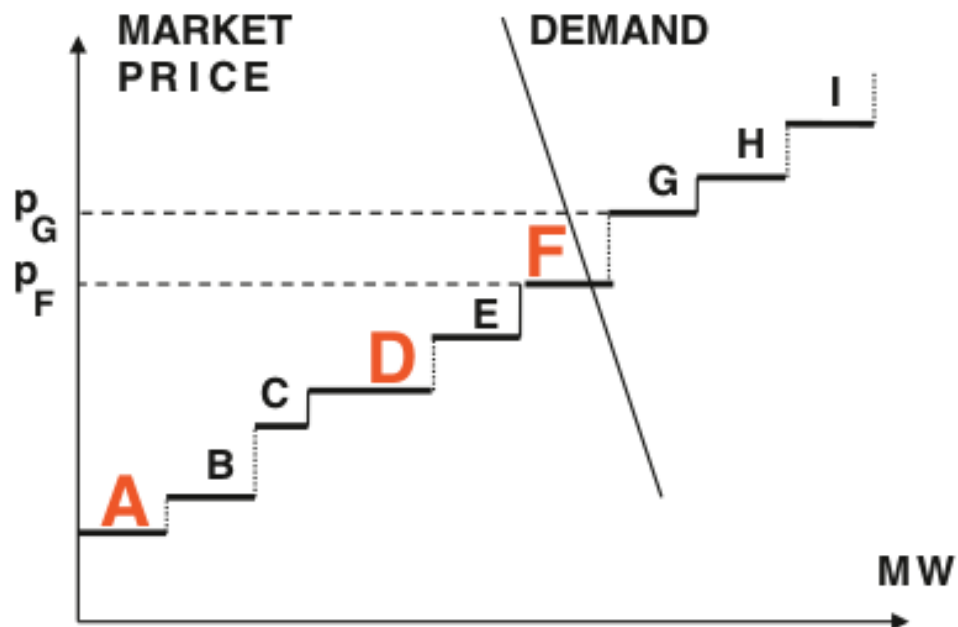


Market Structure

- Number of competitors depends
 - Entry conditions, technical®ulatory barriers
 - Legal constraints, long entry delays, cost disadvantages, uneven access to tech
- Easy market access is perceived as a threat by incumbents
- Barriers
 - Licence, concessions
 - Env regulations
 - Regulation itself
 - Long lead times
 - Experience of incumbents
 - Investments as sunk costs

Simple example

- Ex: market power by ST price manipulation



Market power

- Market power exists when one or several companies are able to exercise some degree of price control for their own benefits
 - There has to be benefit for the company
 - Expected price
 - Ability must be maintained over a significant period of time
 - Existence vs abuse/exercise
 - Depends on structure of the market

Definition by US

- "US Federal Trade Commission and the US Department of Justice define market power as the ability of a single or several competing firms to set prices above their competitive level or consistently withhold supply to raise prices for their own benefit for a given period of time. Note that price dumping, i.e. to lower prices to draw weaker competitors out of a market or to deter entry, is also a manifestation of market power."
- "increased market power" as "the ability of one or more firms to profitably increase prices, reduce output, choice or quality of goods and services, diminish innovation, or otherwise influence parameters of competition".

European legislation

- "dominant position"
- “a position of economic strength enjoyed by an undertaking which enables it to prevent effective competition being maintained on the relevant market by giving it the power to behave to an appreciable extent independently of its competitors, customers and ultimately of its consumers”
 - (a) directly or indirectly imposing unfair purchase or selling prices or unfair trading conditions;
 - (b) limiting production, markets or technical development to the prejudice of consumers;
 - (c) applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage;
 - (d) Making the conclusion of contracts subject to acceptance by other parties of supplementary obligations which, by their nature or according to commercial use, have no connection with the subject of such contracts”

m-firm concentration ratio

$$C_m = \sum_{f=1}^{f=m} \alpha_f$$

α_f represents company f 's market share.

- Aggregate share of m largest companies
- Generally $m \sim 4$
- Or number of companies representing 95%

Hirschman-Herfindahl Index

- R_H or HHI

$$R_H = \sum_f \alpha_f^2$$

- %100 = 10000
- 2500 upper limit for reasonably efficient
- 1000-1800
- Anti-trust policy
- ? 1x30% , 10*7% ? HHI 1390

Use in merger



Merger guidelines and HHI (*Source* [13])



Pivotal Supplier Indicator

- PSI
- A company is pivotal if
 - All other producers can not cover market demand
- PSI is binary
 - Pivotal or not

Residual supply index

- The ratio between the total capacity of all a company's competitors to total demand

$$\begin{aligned} \text{RSI}_f &= \frac{\text{Company } f\text{'s residual supply}}{\text{Total demand}} \\ &= \frac{\text{Total supply capacity} - \text{Company } f\text{'s supply capacity}}{\text{Total demand}} \end{aligned}$$

Lerner index

- A behavioural index that measures market imperfection as overpricing with respect to a perfect market

$$L_I = \frac{p_{\text{realmarket}} - p_{\text{perfectmarket}}}{p_{\text{realmarket}}}$$



What can be done

- Most effective and difficult: Require cap on market share %20-25, force sell the rest
- LT agreements that fix revenues... Virtual power plant
- Remove regulatory difficulties or uncertainties
- Interconnections
- More elastic demand



Collusion and cartel

- Oligopolistic models
- Strategy to maximise joint profits
- Collusion is defined as an explicit or tacit agreement to obtain an objective by gaining an unfair advantage.
- If the agreement is explicit the result is a cartel.



Thank you
Questions

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