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Benchmarking Electricity Distribution Networks

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Overview

- Background to benchmarking
- Methods and applications
- Strategic behaviour
- Lessons

(Incentive) Regulation – History

- Regulation of licensing, obligation to serve, pricing, reliability, safety, theft, etc. date back to early years of the industry (House of Commons, 1882)

- First (incentive) regulations – UK
  - In 1855 – Sliding scale in the Sheffield Gas Act for Sheffield Company, a town gas supplier
  - A similar plan in 1893 for the electricity industry

- Canada – In 1887 – Cost-At- { Ŝ NJ Ø ƛ Ŏ Ŝ LJ f l· y ̆ Ŧ ƨ NJ Company of Toronto
- US ς Sliding scale scheme in Boston Plan of 1906 for price of g (Schmidt, 2000)

Incentive Regulation

- Renewed interest after liberalisation
- Efficiency improvements through penalty/reward

- Benchmarking as a tool for incentive regulation
  - Information asymmetry
  - Mimic market mechanisms / no intervention

- Incentives are strong and work

- But, concerns about unintended consequences, e.g.
  - Fairness
  - Investments
  - Quality of service
  - Innovation
  - Security etc.

Yardstick Incentive Regulation and Benchmarking

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on the performance of other comparable firms

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depend on the efficiency/cost of their rivals

× Instead of using an ex ƴ ű Ŝ LJ NJ Ŝ Ř ƛ Ŏ ű ƛ ƨ ƴ ƨ Ŧ
regulator uses the real data of other firms to estimate the
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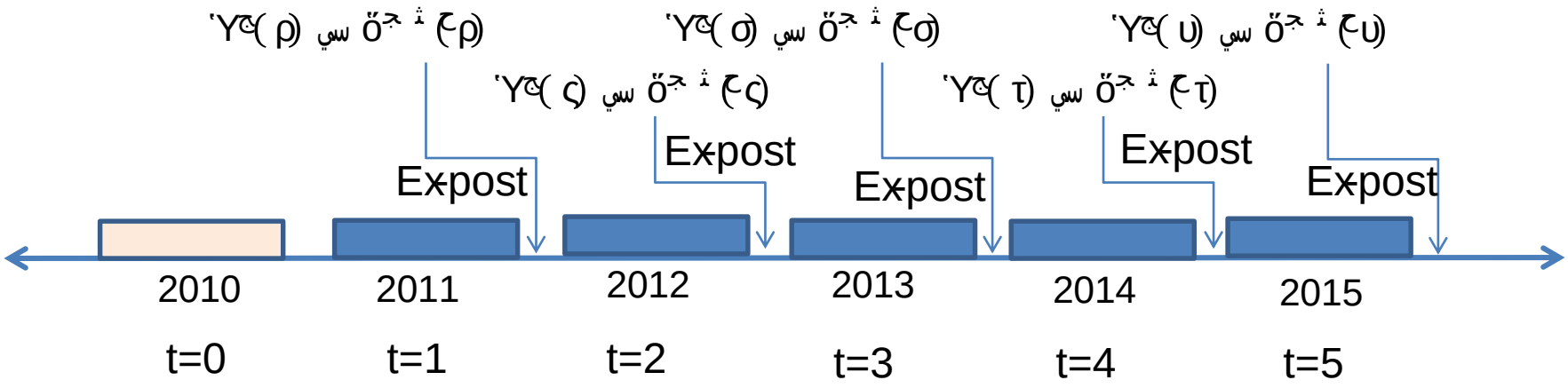
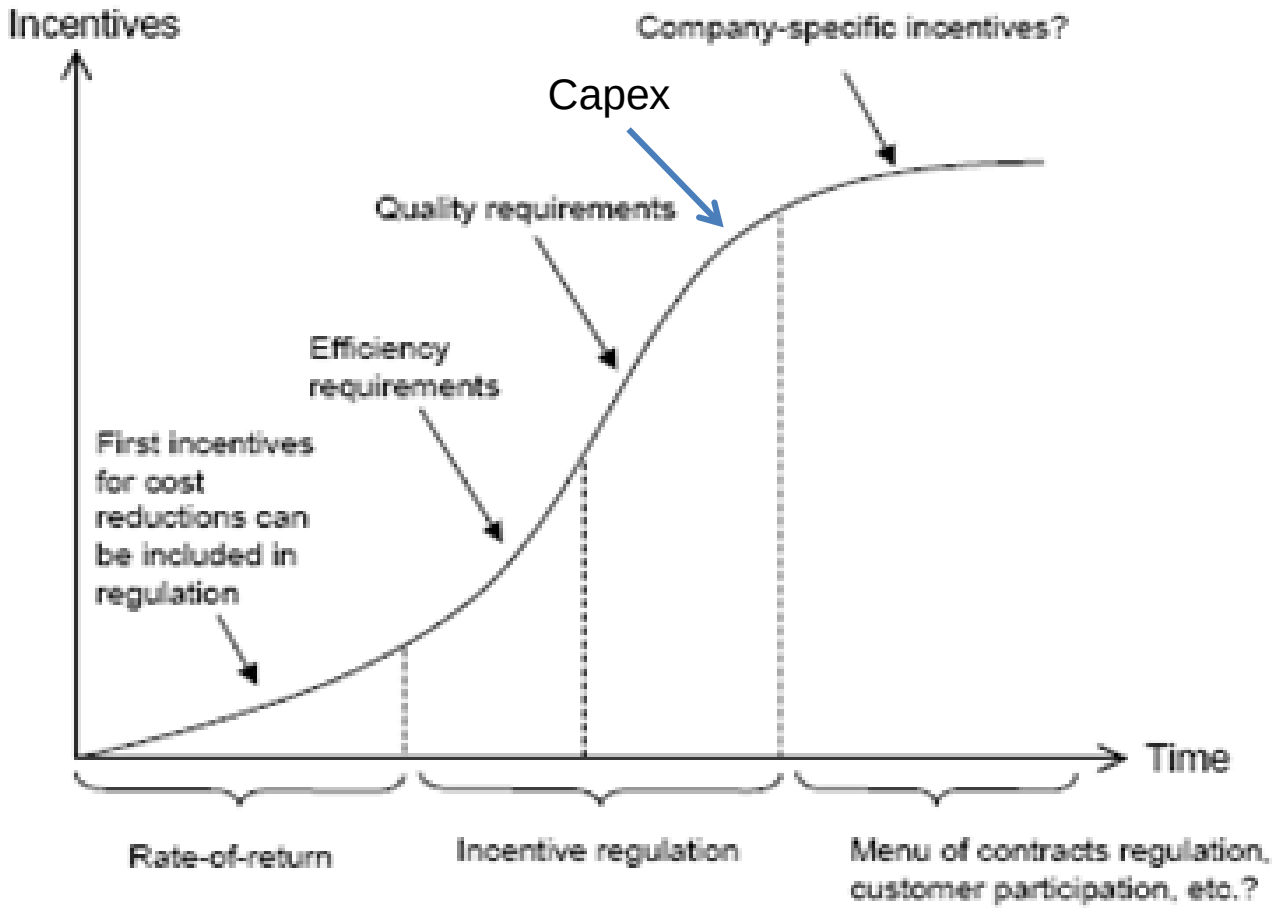
× Allowed revenues/prices not linked to their own costs. This provides incentives to minimize cost.

The Dynamics in Yardstick Competition



Evolution of Regulation & Benchmarking



Source:Viljainen(2005)

Uses of Benchmarking

- Academic research
  - We do efficiency / productivity analysis to try new techniques, investigate features of the sector, and suggest new approaches
- Regulators
  - Direct input in IR benchmarking
  - Informing incentive regulation more broadly
- Self benchmarking
  - Firms benchmarking themselves
- Third parties
  - To inform, and name and shame

Benchmarking Methods

Benchmarking Methods

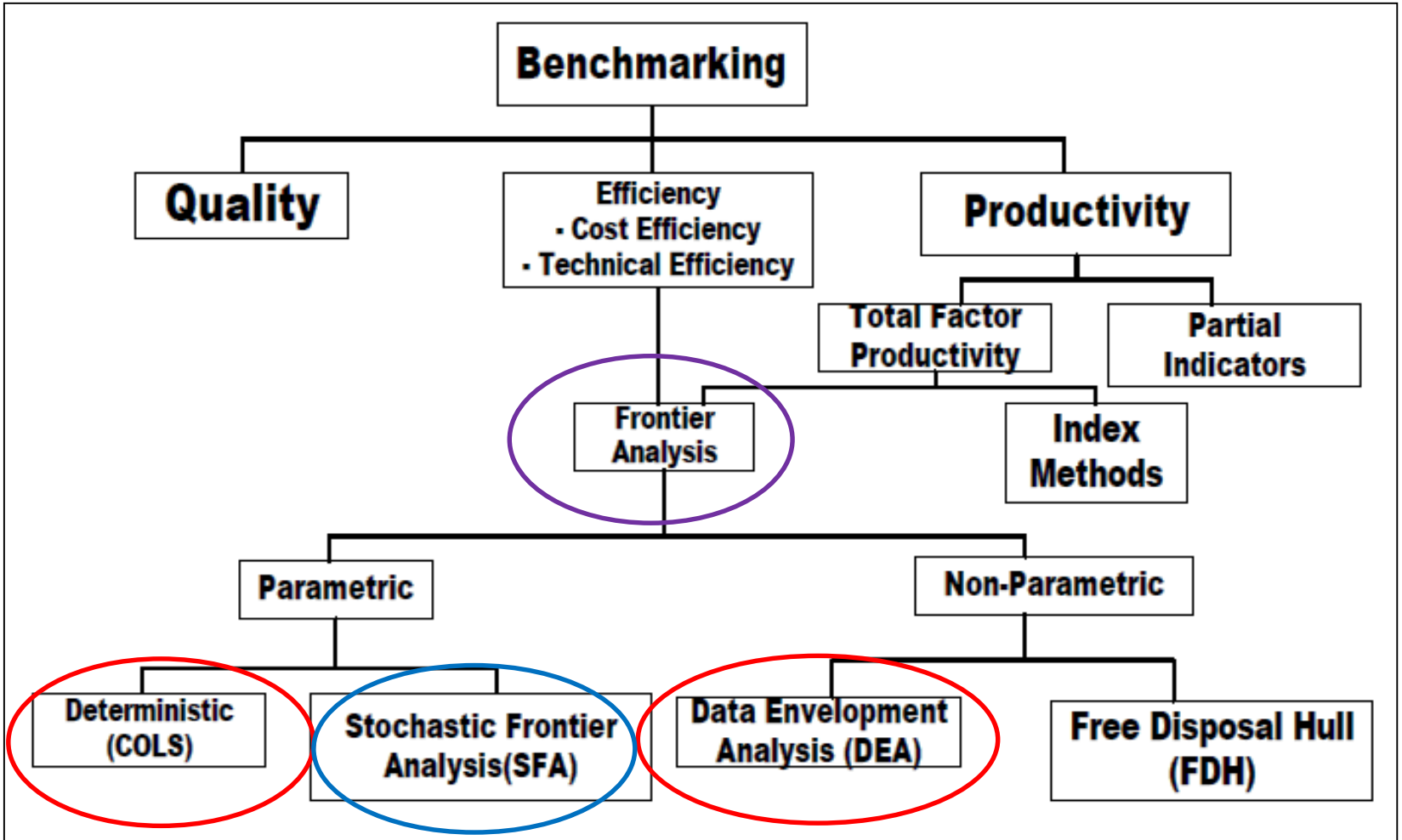


Figure 1. Benchmarking approaches

Source: Khetrapal and Thakur (2014)

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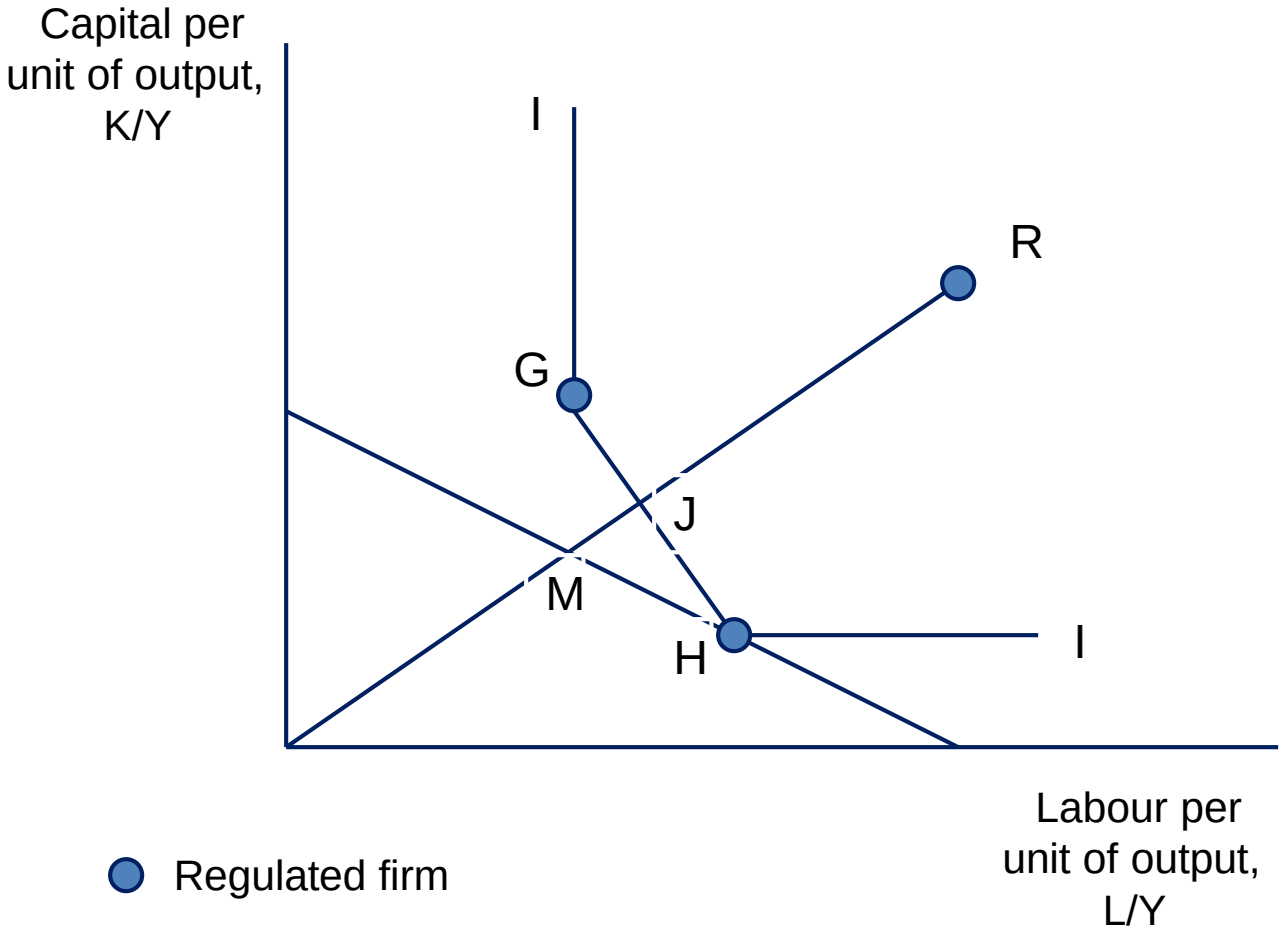
- Frontier/benchmarking models are mathematical/statistical techniques that compare each firm with <u>fully efficient</u> firms
- The efficient cost of each firm is <u>not</u> directly observed, but inferred from the data using frontier techniques

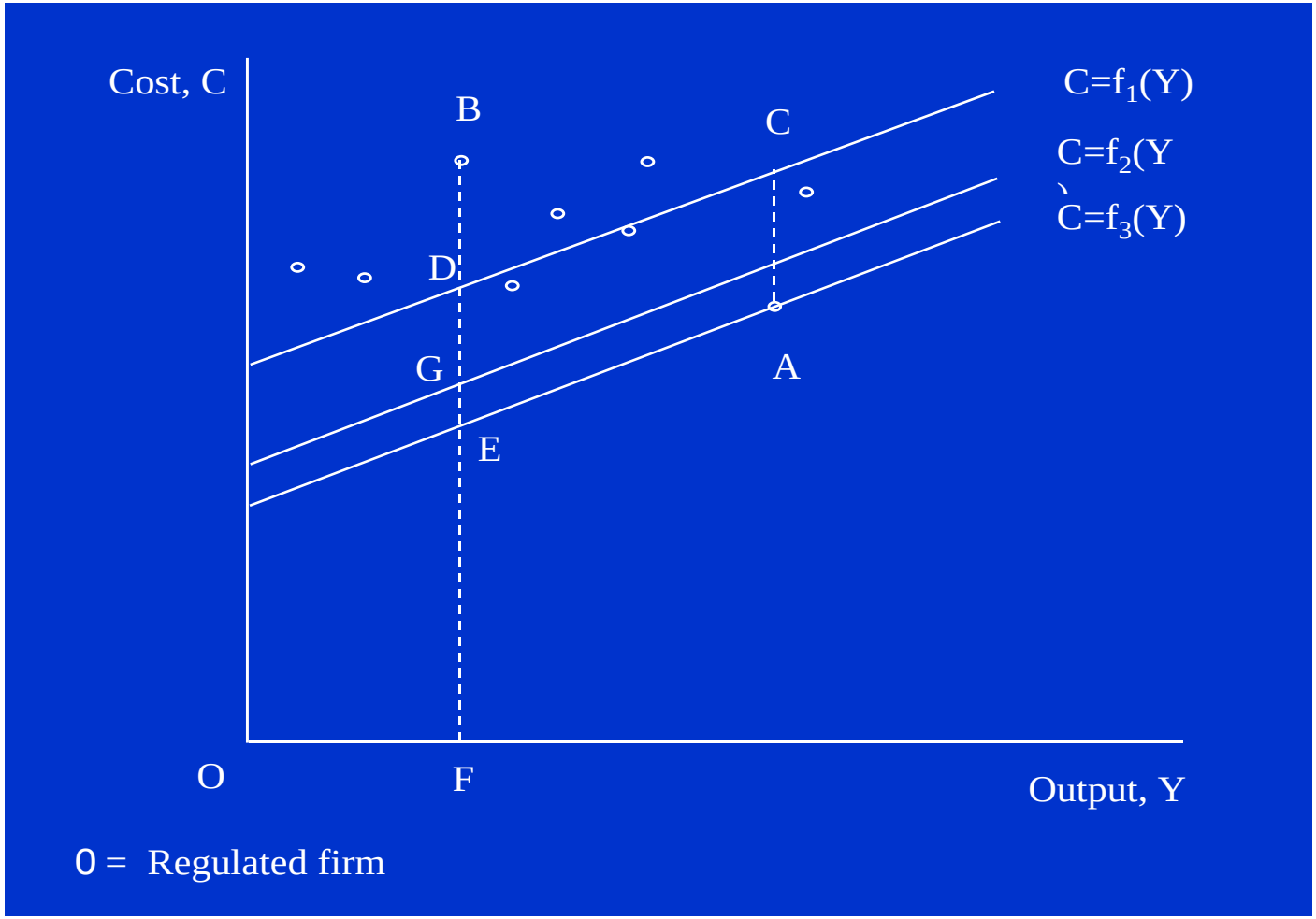
- Frontier techniques
  - Engineering-based techniques
  - Statistical-based techniques
- Statistical-based frontier techniques
  - Non-parametric but deterministic techniques (e.g. DEA)
  - Parametric and stochastic techniques (e.g. SFA)
  - ά ŁōyŜ ú ø Ŝ Ŝ y˝ ε l· LJLJNJ ƨ l· Ŏ K Ŝ ă Σ Ŝ Φ-∃ Φ ă parametric models, random coefficient models, latent class models, etc.

DEA in Practice



Firm R: Techn. eff.= OJ/OR Alloc. eff.= OM/OJ Tot. econ. eff.=OM/OR

Econometric Techniques



SFA efficiency score of B, approximately = GF/BF

COLS efficiency of B = FE / FB

Reference Model – Sweden

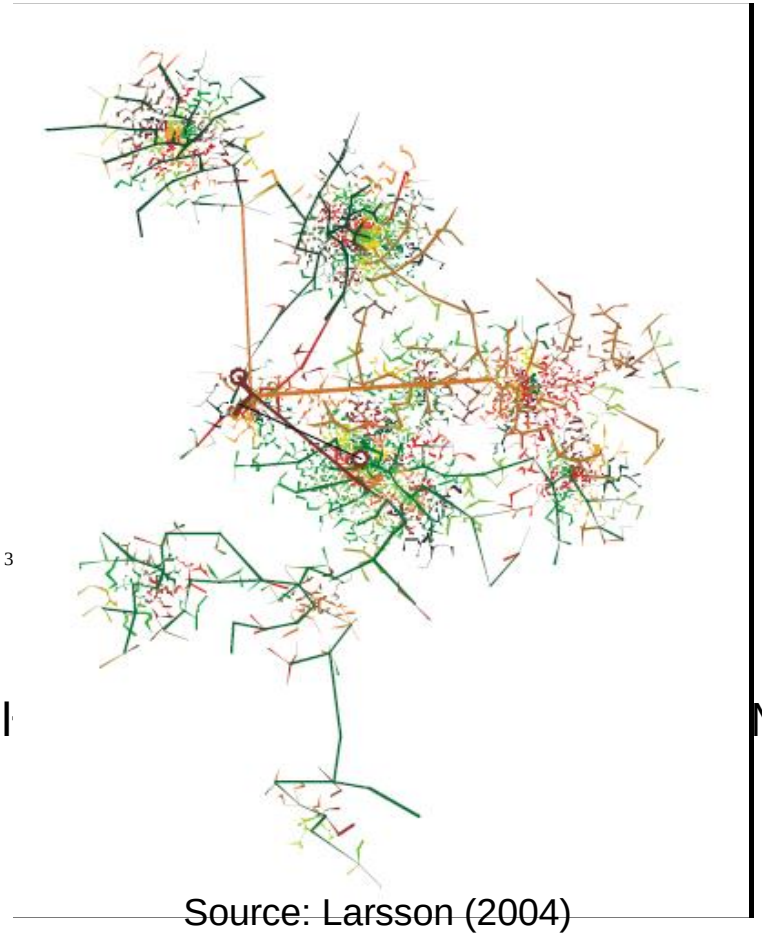
- Several critical parameters derived from hyperbolic tangent functions based on customer density and 5 constants to resemble empirical data

- Paras dependent on customer density:

  - (1) Lines, (2) Back up lines, (3) Back up transformers, (4) Cost of land for transformers, (5) Geometrical adjustment, (6) Energy losses, (7) Interruption cost, (8) Expected interruption cost

$$\text{ModTanh}(x) = (k_1 + k_2 * \tanh(k_3$$

- For each parameter at each voltage level, Ŧ dz ỷ Ŏ ü ƛ ƶ ỷ ă l· NJ Ŝ Ŝ ă ü ƛ Ỳ l NJ Ŝ Ø l· ŧ dz Ŝ ă ε



Source: Larsson (2004)

ï x density (meters of line/customer)
ï *k0, ..., k4* constants

Engineering-Based vs. Statistical-Based Techniques

Statistical-based / real data techniques

	Deterministic	Stochastic
Parametric	Corrected Ordinary Least Squares (COLS)	Stochastic Frontier Analysis (SFA)
Non-parametric	Data Envelopment Analysis (DEA)	Stochastic Data Envelopment Analysis (SDEA)

Source: Cossent (2013)

Engineering-based/ non-real data techniques

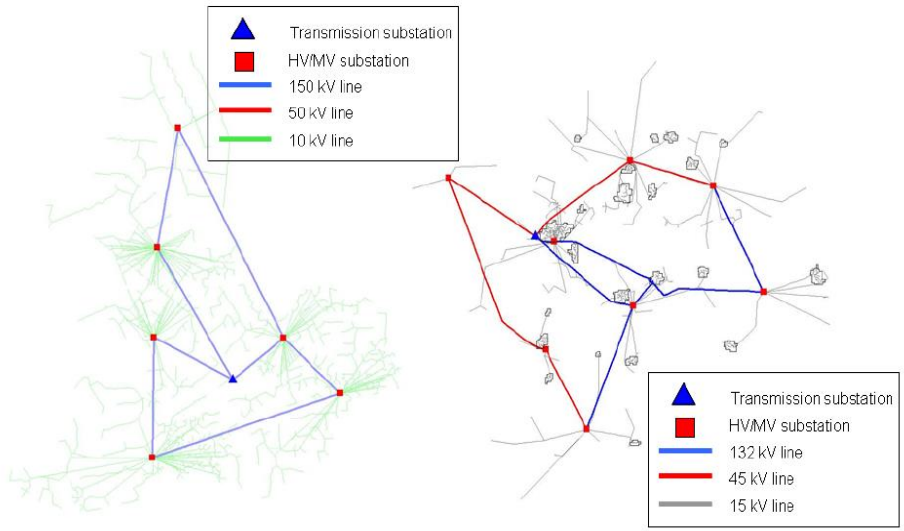


Figure 4-11: Examples of geographical representation of the outputs of RNMs

Source: Cossent (2013)

Reference/Norm models

Table 1: Some European regulation regimes and cost function methodologies for electricity DSOs

Code	Country	Regulation	Benchmark
AT	Austria	Revenue cap	DEA-SFA, best-off
BE	Belgium	Revenue cap	DEA
CH	Switzerland	Cost recovery	Ad hoc
DE	Germany	Revenue cap	DEA-SFA best-off
DK	Denmark	Revenue cap	COLS-MOLS
ES	Spain	Revenue cap	Engineering
FI	Finland	Revenue cap	DEA w. SFA back-up
FR	France	Cost recovery	Ad hoc
GB	Great Britain	Revenue cap	COLS and Ad hoc
GR	Greece	Cost recovery	Ad hoc
HU	Hungary	Price cap	Ad hoc
IRL	Ireland	Price cap	Ad hoc
NL	Netherlands	Yardstick comp	DEA-OLS-MOLS
NO	Norway	Yardstick comp	DEA
SE	Sverige	Revenue cap	Engineering and DEA

Source: Benchmarking and regulation, Per Agrell, Peter Bogetoftb,
Preprint submitted to DEA Journal November 14, 2012

Benchmarking Evaluation Criteria

- Model variables
- Efficient comparators
- Consistency of results
- Quality of service
- Sufficient investments
- Long-term innovation
- Uncertainty
- Transparency

Consistency Conditions for Frontier Models

Mutual-consistency conditions	1. Efficiency scores obtained with different methods should have similar distributional properties (mean, dispersion, etc.)
	2. Different methods should provide a similar ranking of firms
	3. Different methods should identify the same best and worst firms
Consistent-with-reality conditions	4. All approaches should be stable over time
	5. Efficiency scores should be consistent with the actual market conditions
	6. Inefficiencies obtained with frontier methods should be consistent with other methods such as finantial ratios

Table 4-2: Consistency conditions for frontier benchmarking methods (Bauer et al., 1998)

Source: Cossent (2013, p. 81)

DNO Benchmarking: Example – Norway