

# Productivity and Efficiency Analysis

## 1) Introduction

*c) Productivity analysis in action: Incentive regulation of electricity distribution networks*

**Timo Kuosmanen**

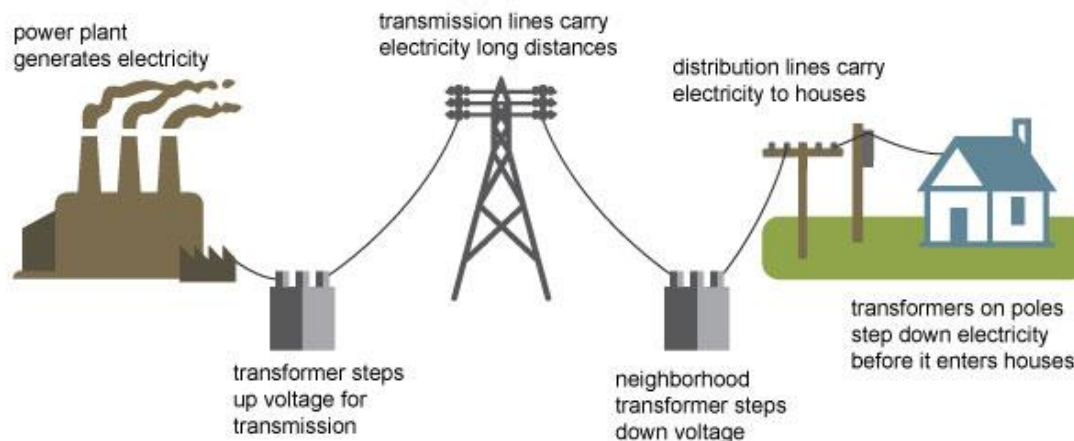
Aalto University School of Business

<https://people.aalto.fi/timo.kuosmanen>

# Supply chain of electricity

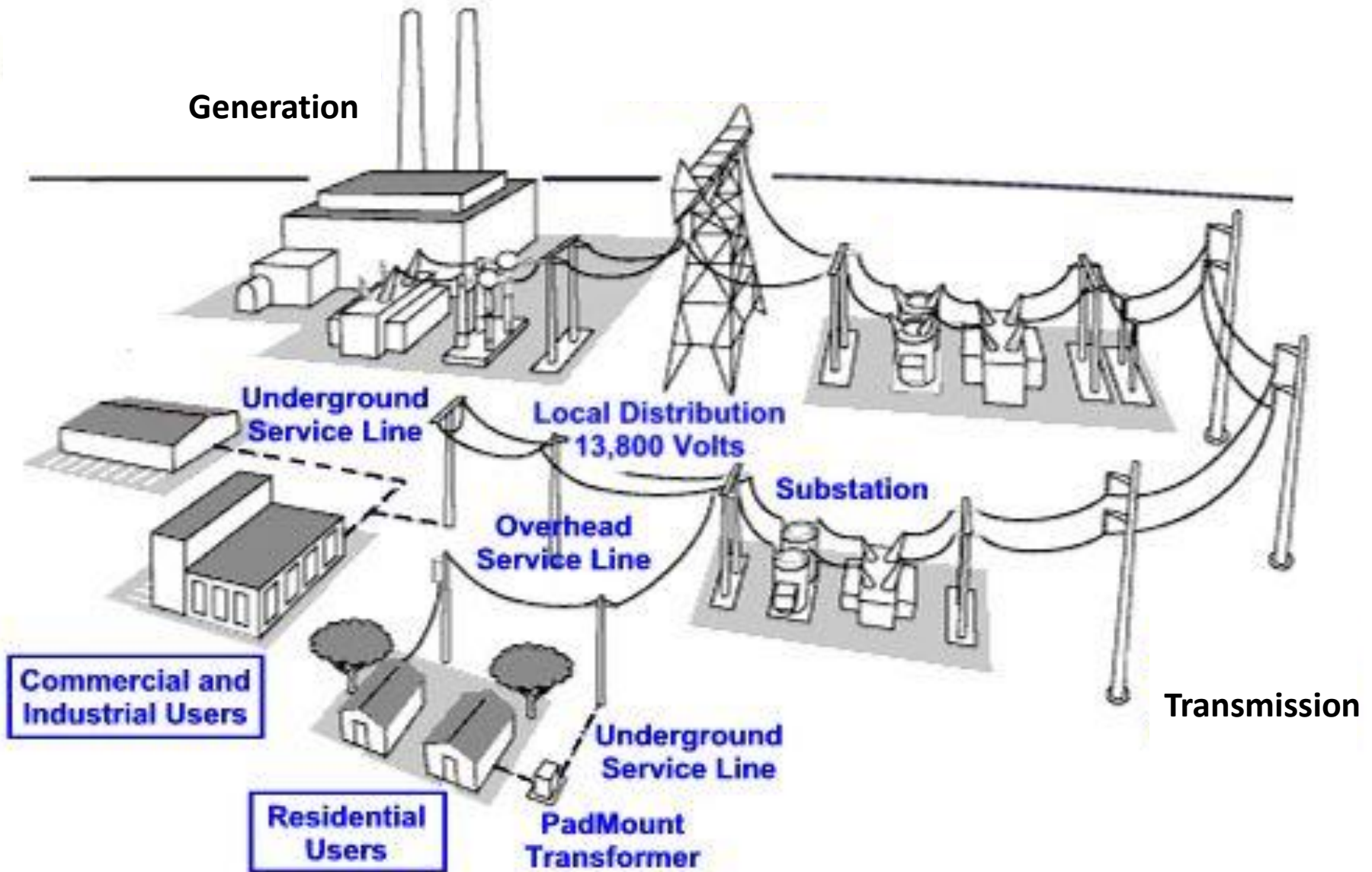
- **Electricity generation:** competitive market with many buyers and sellers (Nord Pool energy exchange)
- **Transmission:** national monopoly (1 TSO)
- **Distribution:** local monopolies (currently 77 DSOs)

## Electricity generation, transmission, and distribution



Source: Adapted from National Energy Education Development Project (public domain)

**Generation**



# Electricity distribution is a natural monopoly: how to prevent "legalized robbery" of consumers?



# Yardstick competition

■ Yardstick competition describes the simultaneous regulation of identical or similar firms. Under this scheme the rewards of a given firm depend on its standing *vis-à-vis* a shadow firm, constructed from suitably averaging the choices of other firms in the group. Each firm is thus forced to compete with its shadow firm. If firms are identical, or if heterogeneity is accounted for correctly and completely, the equilibrium outcome is efficient.

A Theory of Yardstick Competition

Author(s): Andrei Shleifer

Source: *The RAND Journal of Economics*, Vol. 16, No. 3 (Autumn, 1985), pp. 319-327

# Yardstick competition

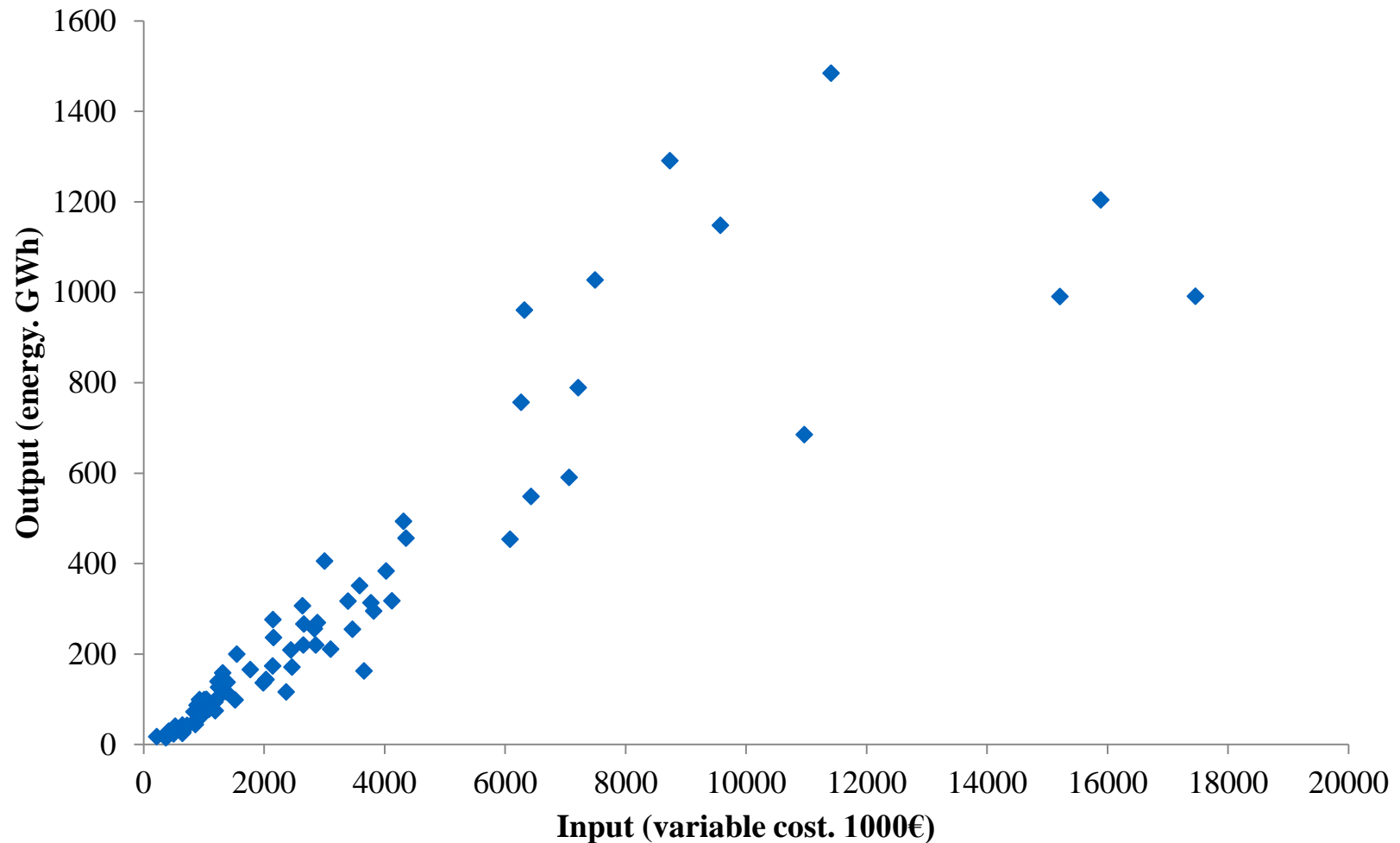
□ **“Reduced-form” regulation.** Sorting firms into identical or even similar groups to apply yardstick competition is a very inefficient use of information. Even though implementing yardstick competition requires only two identical firms, there may be firms with no identical twins. The regulator can avoid this problem if he observes the characteristics that make firms differ, and corrects for this heterogeneity. This correction amounts to a regression of costs on characteristics that determine diversity, as I shall show for the case of marginal cost pricing.

A Theory of Yardstick Competition

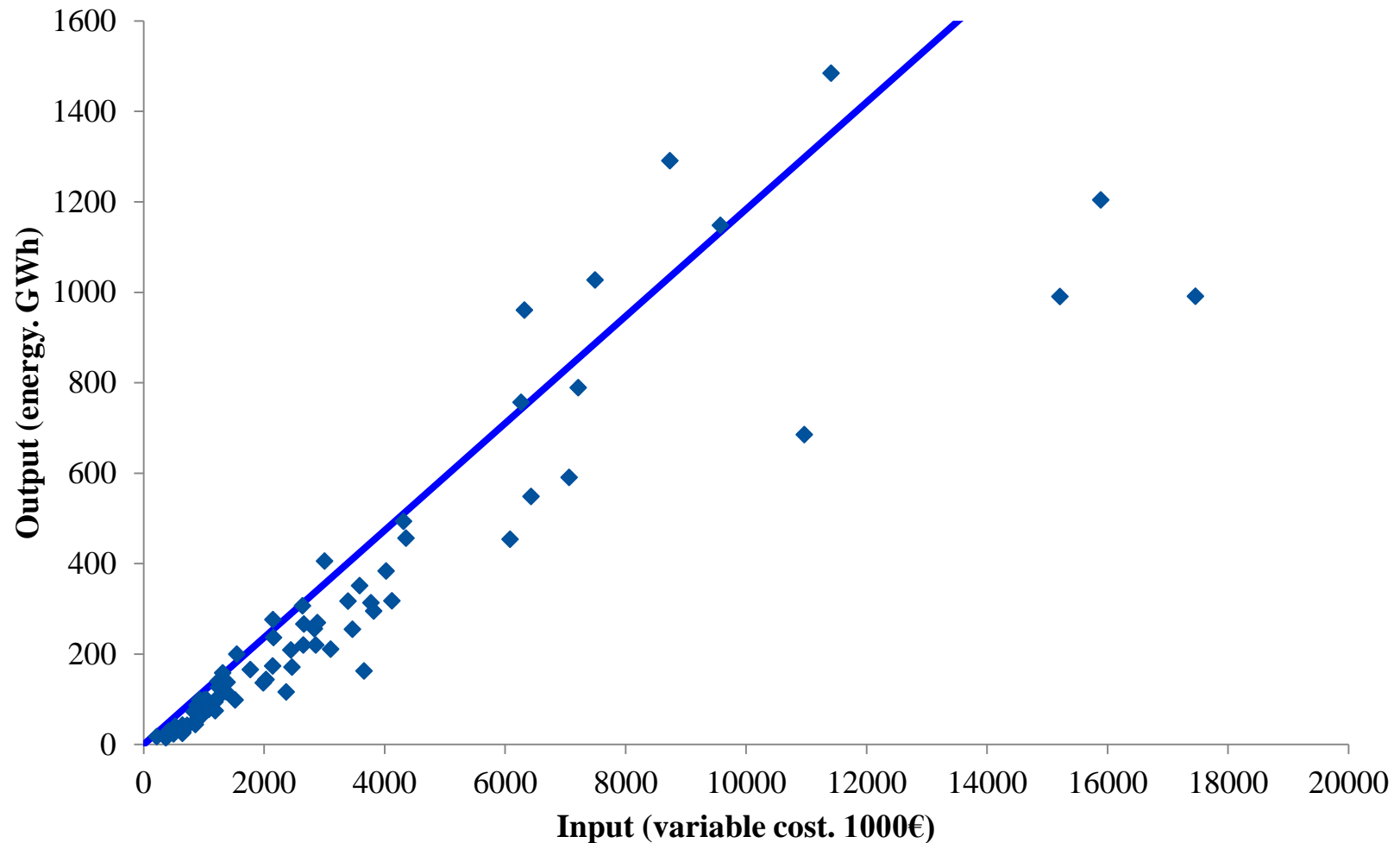
Author(s): Andrei Shleifer

Source: *The RAND Journal of Economics*, Vol. 16, No. 3 (Autumn, 1985), pp. 319-327

# Illustration of cost dispersion in Finland



# Illustration of yardstick





# Finnish regulation model: conditional yardstick competition

Revenue cap = acceptable total cost

- Fixed cost (capital):
  - Market rate of return for capital (CAPM model)
- Variable cost (OPEX):
  - Efficient variable cost frontier as the benchmark (given the capital stock and output demand)

Kuosmanen (2018) Conditional yardstick competition:

[https://www.researchgate.net/publication/328602457\\_Conditional\\_yardstick\\_competition](https://www.researchgate.net/publication/328602457_Conditional_yardstick_competition)

# Evolution of the variable cost frontier in the Finnish electricity distribution regulation

- 1st regulation period (2005-2007), **DEA**
- 2<sup>nd</sup> regulation period (2008-2011), Average of **DEA** and **SFA**
- 3<sup>rd</sup> regulation period (2012-2015): **StoNED**
- 4<sup>th</sup> and 5<sup>th</sup> regulation periods (2016-2019, 2020-2023): Panel data **StoNED** with multiple inputs and outputs

## Cost frontier model (2012-2015)

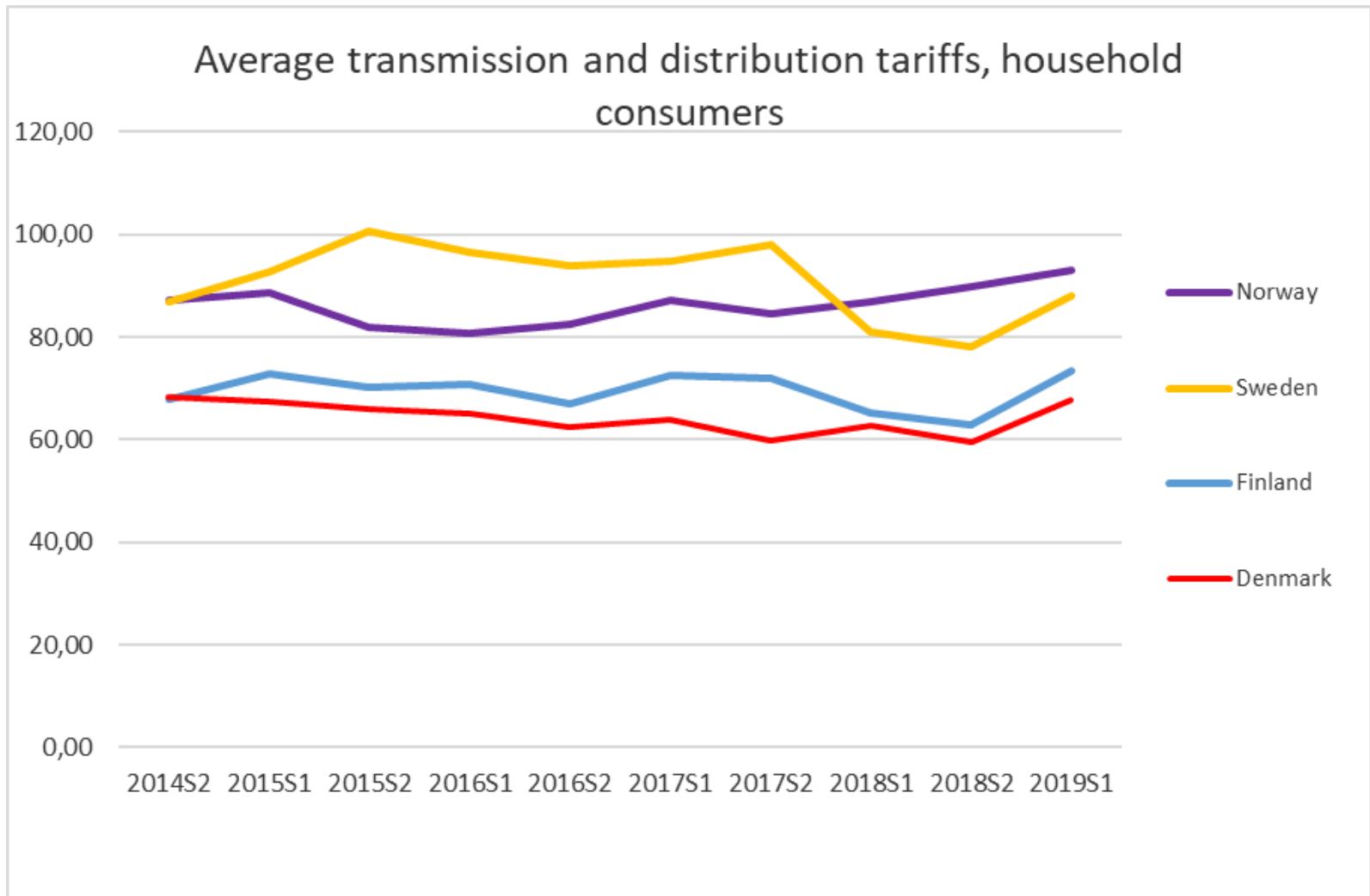
$$\ln x = \ln C(y_1, y_2, y_3) + \delta z + u + v$$

- $x$  is the total cost
- $C$  is the frontier cost function
- $y_1$  is the energy transmission (GWh of 0.4 kV equivalents)
- $y_2$  is the total length of the network (km)
- $y_3$  is the number of customers connected to the network
- $z$  is the proportion of underground cables (%)
- $u$  is an asymmetric inefficiency term
- $v$  is a random noise term

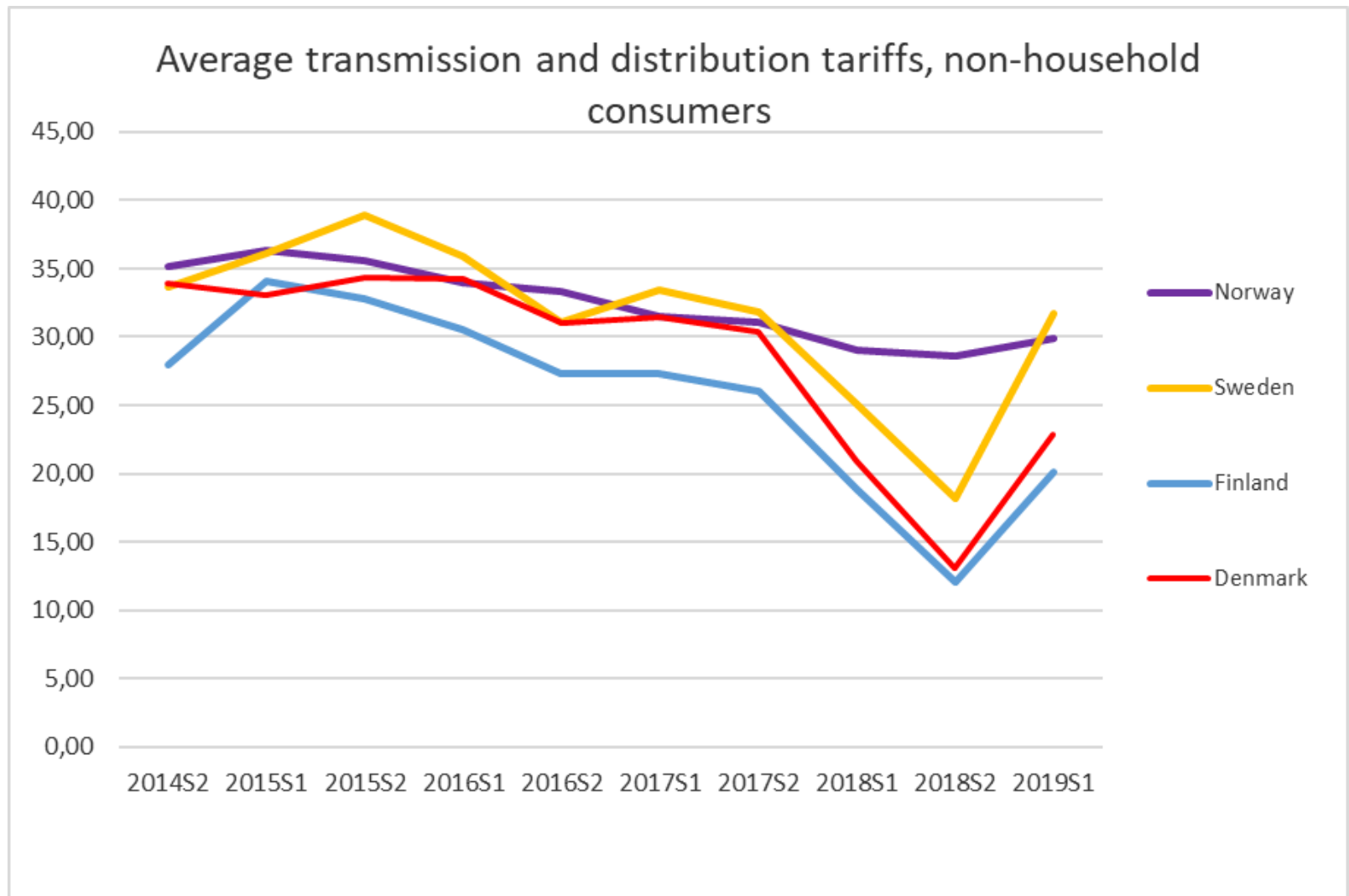
## A note on variables

- Total cost = OPEX + TP + KAH
  - OPEX = Operating expenditure (incl. wages)
  - TP = capital cost (depreciation)
  - KAH = cost of interruptions
- Energy (GWh of 0.4kV equivalent)
  - Different voltage levels (0.4kV, 1-70kV, 110kV) weighted by average transmission tariffs

# Comparison transmission and distribution tariffs in the Nordic countries



# Comparison transmission and distribution tariffs in the Nordic countries



# Next lesson

2 Data envelopment analysis (DEA)

2a) Application of DEA