EFFICIENCY AND PRODUCTIVITY MEASUREMENT FOR REGULATION PURPOSES

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Outline

- A primer on efficiency measurement
- Performance measurement terminology
- Total factor productivity decomposition
- Model and data specification issues
- Quality & Environment
- Capital measurement
- Conclusions

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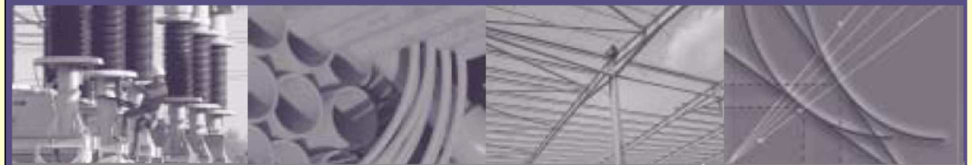

A Primer on Efficiency Measurement for Utilities and Transport Regulators

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WBI DEVELOPMENT STUDIES

The Primer goals

- Primer for regulators of public service firms recently “privatized” in less developed countries
  - *Electricity production, transmission and distribution*
  - *Water and gas distribution*
  - *Telecoms, ports, airports, railways,...*
- Efficiency measures for the control of regulated firms
- To be used in the process of price revision in order to ensure:
  - A certain degree of *yardstick competition*
  - Keeping a satisfactory level of investments
  - Consumers participating (*sharing*) in productivity gains

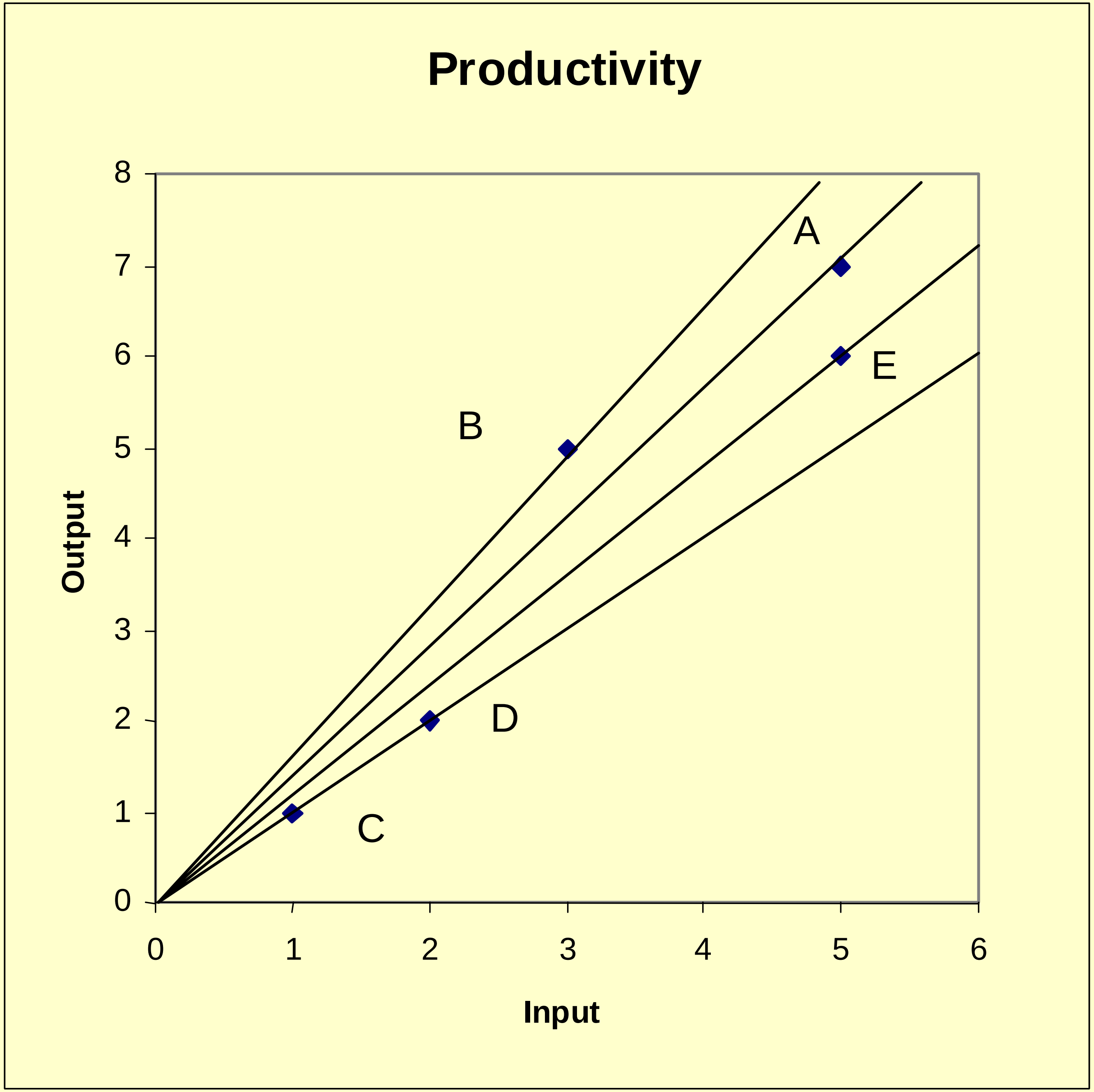
Why to use sophisticated measurement methods?

- In principle, a simple productivity measure could be used for regulation purposes (e.g. €/Kwh)

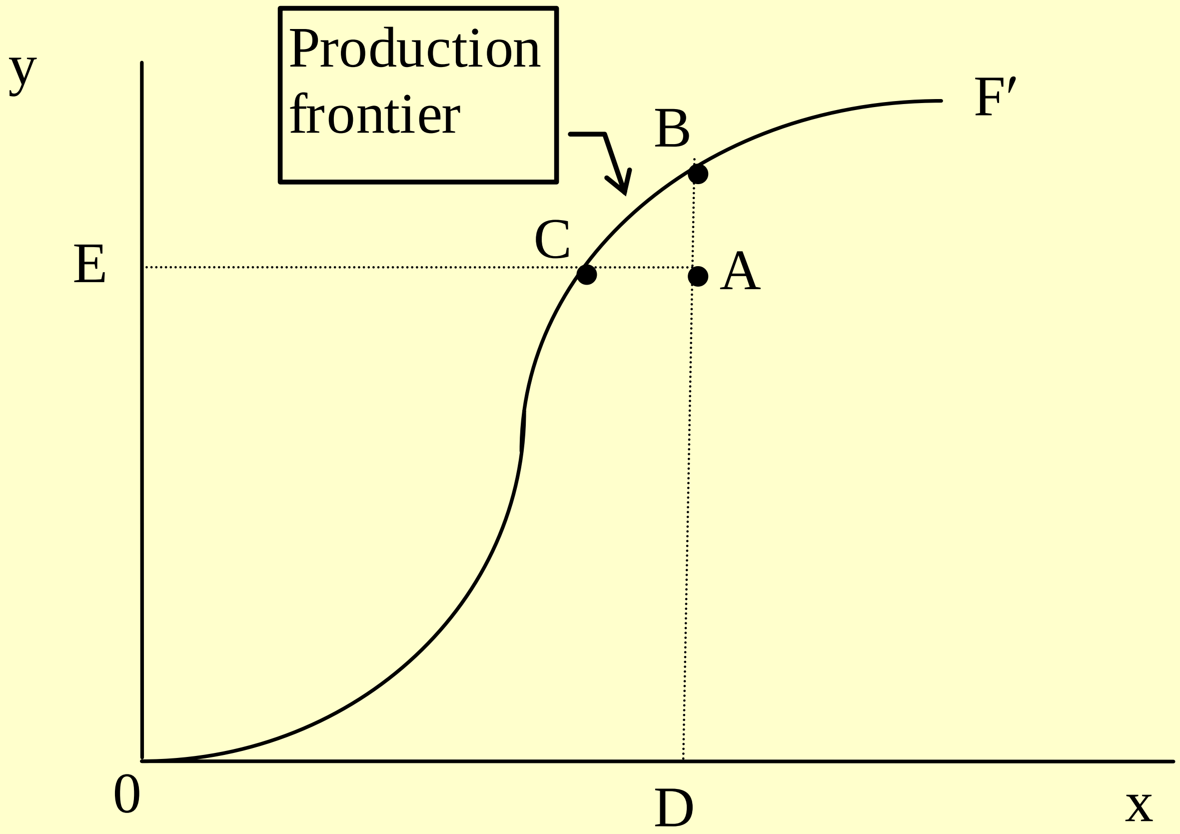
- However several problems may appear:
  1. Potential differences in *output composition*
  2. Differences in *scale of production*
  3. *Input prices* varying from one firm to the other and over time
  4. Productivity growth in last period could be partly due to *catching-up*
  5. It could be that not all companies face identical conditions for growth, e.g. if they are located in areas with low expected population growth

Performance measurement terminology

- productivity
- total factor productivity
- production frontier
- technical efficiency
- allocative efficiency
- cost efficiency
- revenue efficiency
- output vs. input orientation
- technical change
- efficiency change
- scale efficiency
- constant returns to scale
- point of (technically) optimal scale
- feasible production set
- output-mix allocative efficiency
- Malmquist index


Productivity
Output
Input
0
1
2
3
4
5
6
7
8
0
1
2
3
4
5
6
A
B
C
D
E

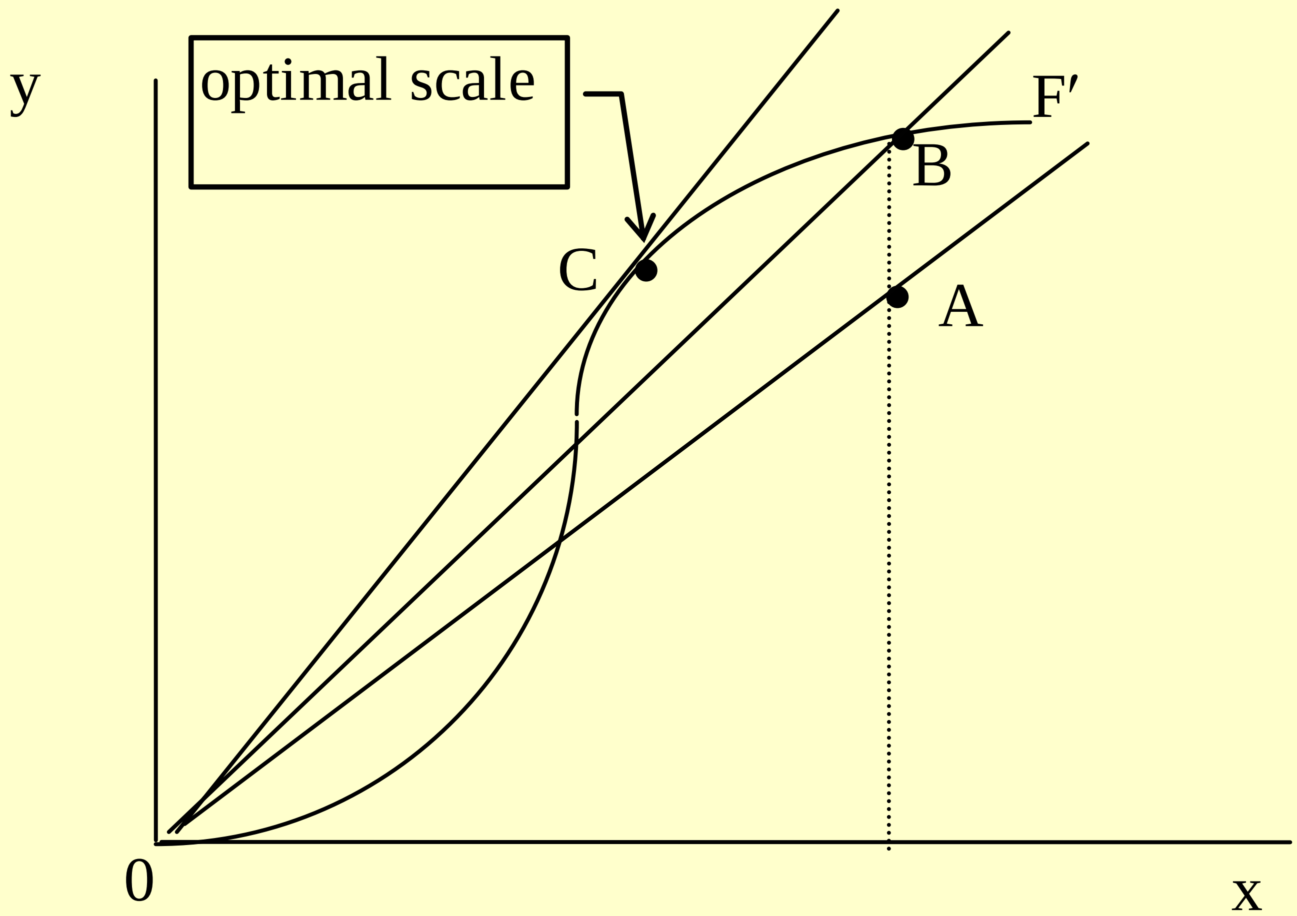
Production frontier, technical efficiency, output vs. input orientation



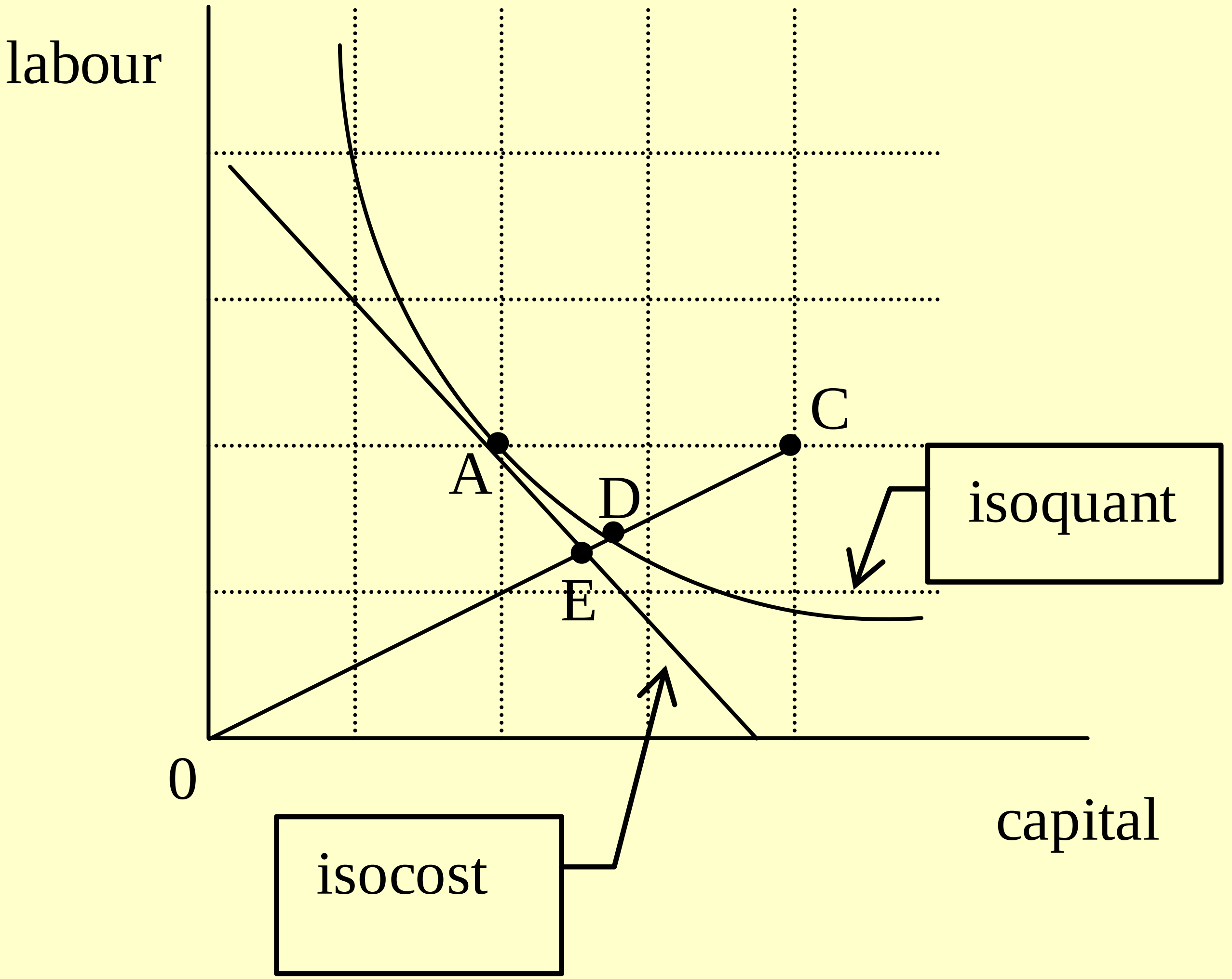
$TE_O = DA/DB$

$TE_I = EC/EA$

Scale efficiency



Cost and allocative efficiency



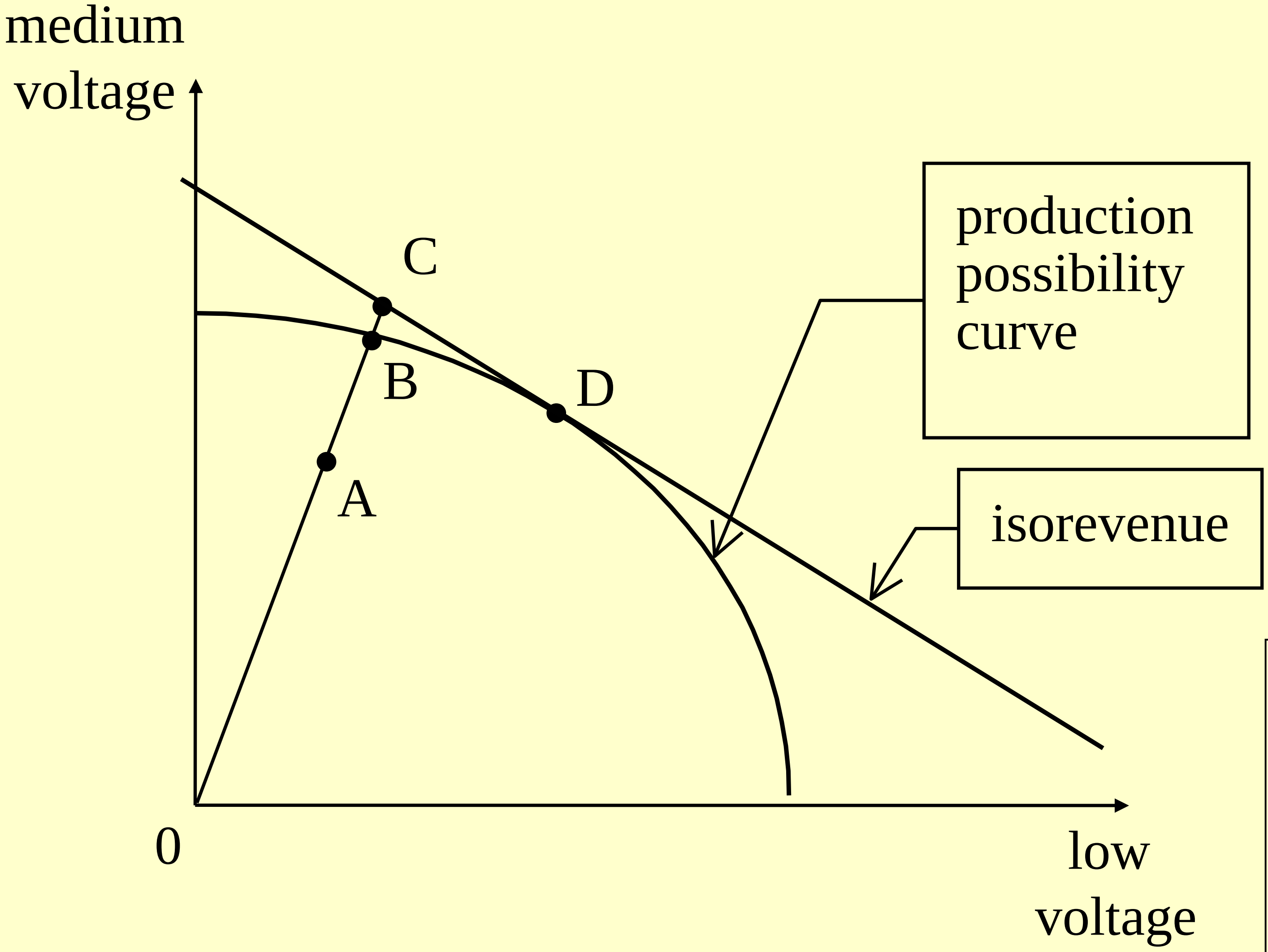
TE=0D/0C

AE=0E/0D

CE=0E/0C

=TE×AE

Revenue and allocative efficiency



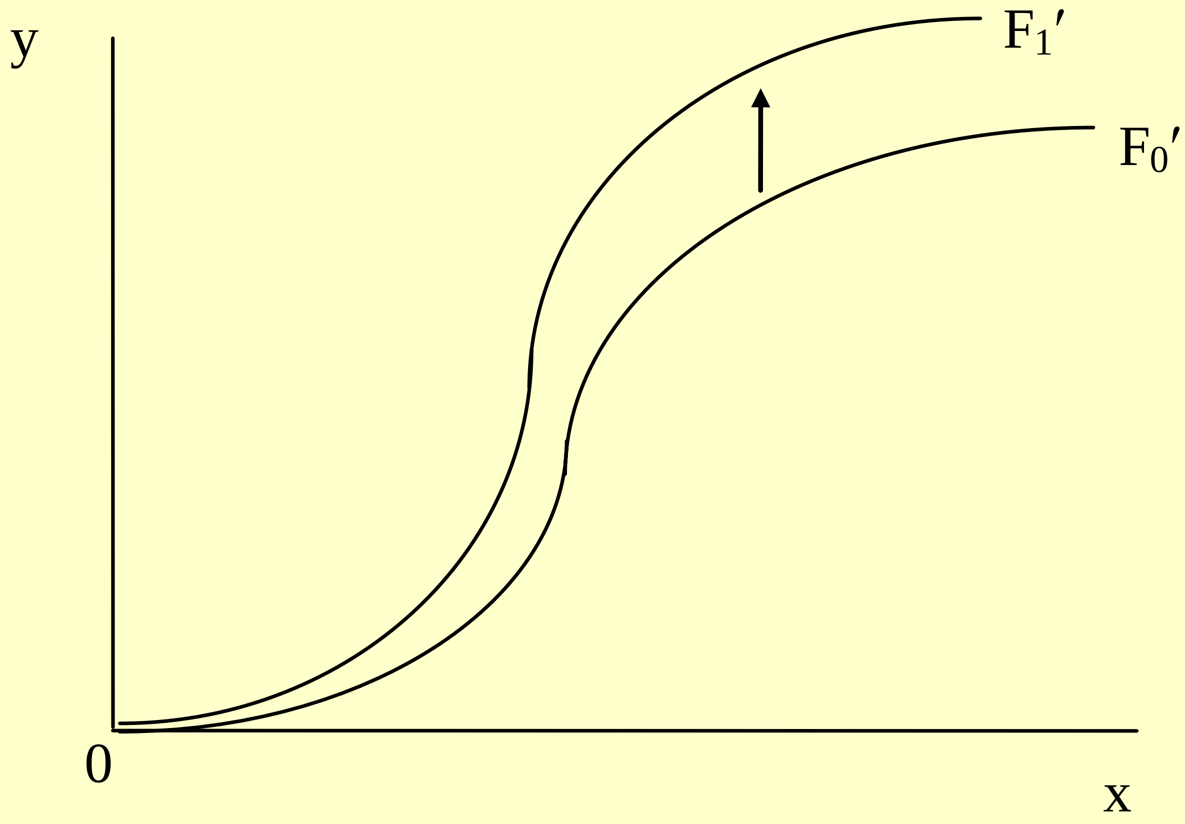
$TE_O = 0A/0B$

$AE_O = 0B/0C$

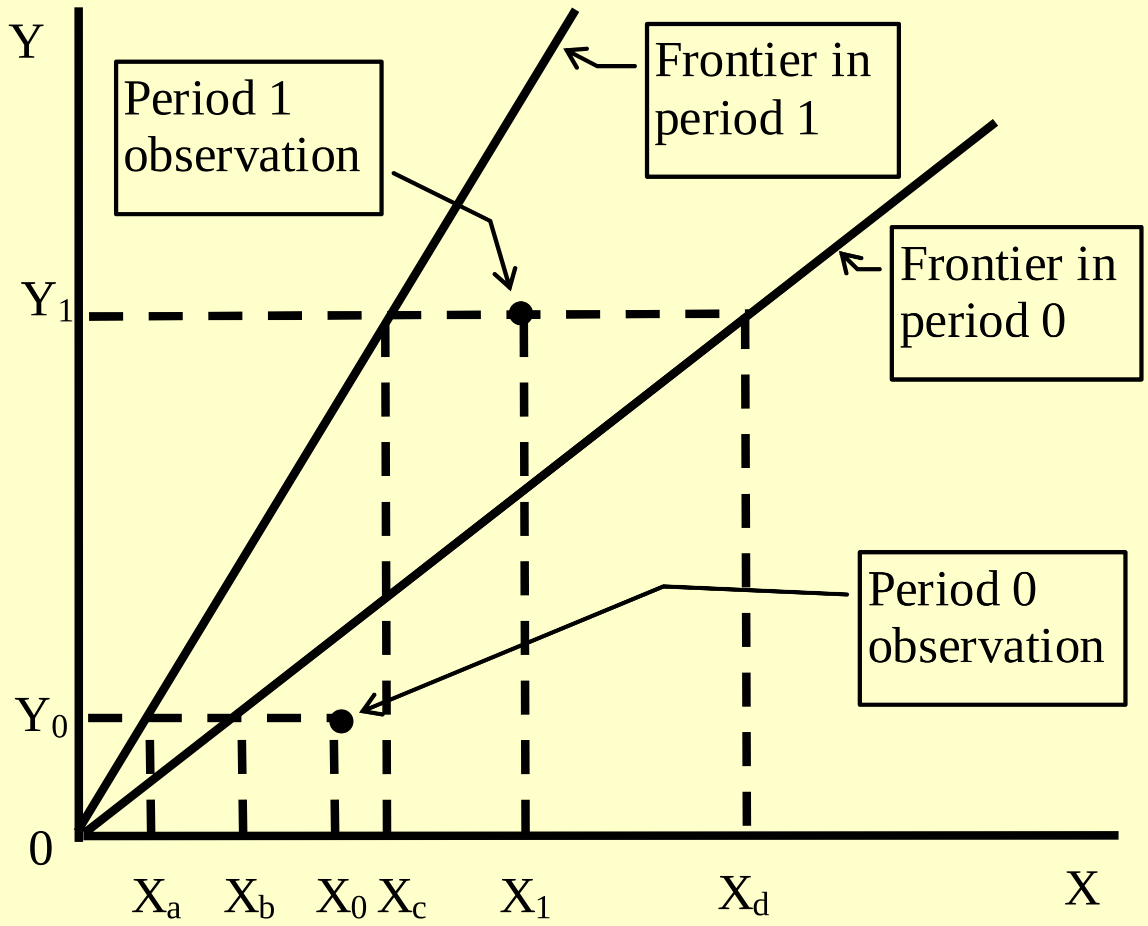
$RE = 0A/0C$

$= TE_O \times AE_O$

Technical change



TPF change Malmquist index decomposition



Technical efficiency change: TEC = $(X_0/X_b)/(X_1/X_c)$

Technical change (period 0): TC = $(X_0/X_a)/(X_0/X_b)$

TFP change (Malmquist index): TFPC = TEC×TC

$= (X_0/X_1)/(X_b/X_c)\ /(X_c/X_d)$

Total Factor Productivity

- With one output (**Y_1**) and one input (**X_1**) TFP is given by:

$$TFP = Y_1/X_1$$

- And in the multi-output (**M**) multi-input (**K**) case:

$$TFP = \frac{\text{output index}}{\text{input index}} = \sum_{m=1}^{M} a_m Y_m \Big/ \sum_{k=1}^{K} b_k Y_k$$

where a_m and b_k indicate relative output and input shares:

- Observed shares: Price Index Numbers (**PIN**)
- Shadow shares: Data Envelopment Analysis (**DEA**)
  (non-parametric, deterministic)
  Stochastic Frontier Analysis (**SFA**)
  (parametric, stochastic)

Total factor productivity decomposition

- **TFP level**
  - technical efficiency (**TE**)
  - scale efficiency (**SE**)
  - allocative efficiency (**AE**): *input and output mix*

- **TFP change**
  - technical efficiency change (**TEC**): *catching-up*
  - scale efficiency change (**SEC**)
  - allocative efficiency change (**AEC**): *input and output mix*
  - technical change (**TC**)

Factors potentially out of the control of firms

- **Scale efficiency**

  Size expansion or size reduction is generally not possible, at least in the short run

- **Allocative efficiency**

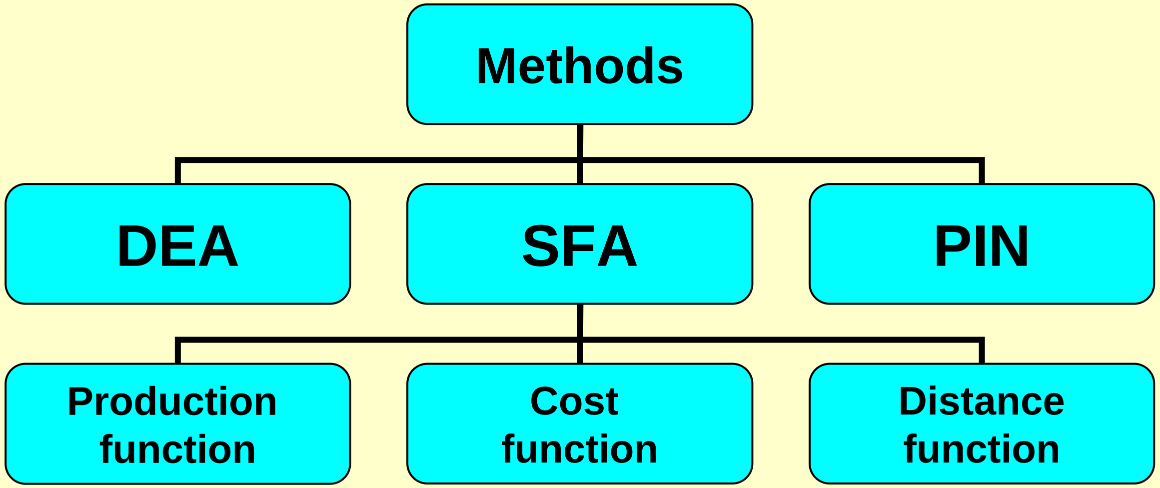
  Excess capital or excess labor are very often the result of past situations and need time to be adjusted. In the meantime:

  - wait for demand to increase
  - replace the asset, remove excess labor
  - write-down the value of excess assets or labor

  In some cases the labor input requirement is embodied in capital

  Also output combinations may not correspond to the optimum situation, given the demand structure

Method selection



- SFA and DEA are more data demanding, PIN is an option but can not be decomposed
- SFA allows taking into account environmental factors more easily
- Production and cost functions estimations give different results as a consequence of divergent objectives and/or allocative distortions
- Distance functions and cost functions allow multi-output multi-input technologies

Model and data specification issues

- Need enough data of sufficient quality:
  - *"garbage in = garbage out"*
- Degrees of freedom
  - *limitations to the number of dimensions (variables and/or parameters)*
- Physical quantities vs. monetary values
  - *possibilities of aggregation under certain conditions*
- Panel data is a must for regulation purposes
  - *TFP change and its decomposition*
- International benchmarking is desirable
  - *but data comparability may be a problem*

Inputs

<u>Labor</u> *Aggregation across categories implicitly assume uniform skills across firms*

<u>Capital</u> *Aggregation issues: lines overhead or underground;*
poles may be wooden, concrete or steel;
low or medium voltage lines, type of transformers,…

Distinguishing lines and transformers takes better into account population density issues

Ideally a measure of the potential service flow, but requires an accurate computation of capital values

<u>Other inputs</u> *"out-sourcing", price deflators, overhead costs, capital expenditures vs. maintenance expenditures*

Output and price issues

- **Output**

  - Demand-based vs. supply-based measures

  - Quantities delivered and number of customers

  - Differentiating between customer types

  - Demand peak, “bad” outputs (pollution)

  - The network: output or input?

- **Prices**

  - Needed to estimate allocative (*input or output mix*) efficiencies

  - And to decompose cost and revenue efficiency

  - CPI vs. specific input price indexation

  - Lack of price variation between firms can be a problem

Quality & Environment

- **Quality**

  - Need for homogeneous definitions (*e.g. reliability of supply*)

  - Output quality may be addressed with multi-output functions

  - Quality out of the model? An option, if minimum standards are imposed

  - Quality within the model? If potential trade-offs between quality and quantity is a key issue

- **Environment**

  - Sector specific: density, climatic, geographic variables

  - Defining suitable measures can be tough (*e.g. population density*)

  - Each firm will argue for variables that will make it look better

  - Z variables in the model?

Capital measurement: a challenge!

Quantity of capital

- Capital quantity should reflect the potential service flow (economic depreciation)
- Depreciation expenses maybe a good proxy if firms assume similar asset lives and depreciation paths
- Investment patterns can be extremely lumpy and differ by firm
- These problems can be overcome when are available:

  - A full history of investment expenditures by firm, and
  - Good indexes of price inflation over the whole period

Cost of capital = Depreciation + interest costs (of debt *and* equity)

Price of capital = Cost / Quantity

Capital quantity: choosing an “ideal” measure

Quantity = the real purchase price of each asset (X) divided by its asset life (L) is allocated to each year

Cost = take the real purchase price of each asset, and then using the real discount rate convert this into L equal repayments in each year (an annuity)

Options (see Primer Appendix Example)

1. Depreciated nominal value (from books)
2. Undepreciated nominal value (from books)
3. Depreciated replacement value (using data on full history of investment)
4. Undepreciated replacement value (using data on full investment history) = “ideal”

Conclusions

To summarize, there are particular aspects that may be taken into account, after a feasibility study, in next regulation revisions:

1. The distinction among TFP components “under control” and otherwise
2. International benchmarking
3. Quality being part of the model specification
4. An “ideal measure of capital