Benchmarking Analysis in in Transmission and Distribution of Electricity

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Mehdi Farsi, Aurelio Fetz, Massimo Filippini

Center for Energy Policy and Economics
Swiss Federal Institutes of Technology
ETH Zentrum, WEC
CH-8092 Zurich, Switzerland

Outline

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- **Introduction**
- **Empirical Analysis**
- **Conclusion**

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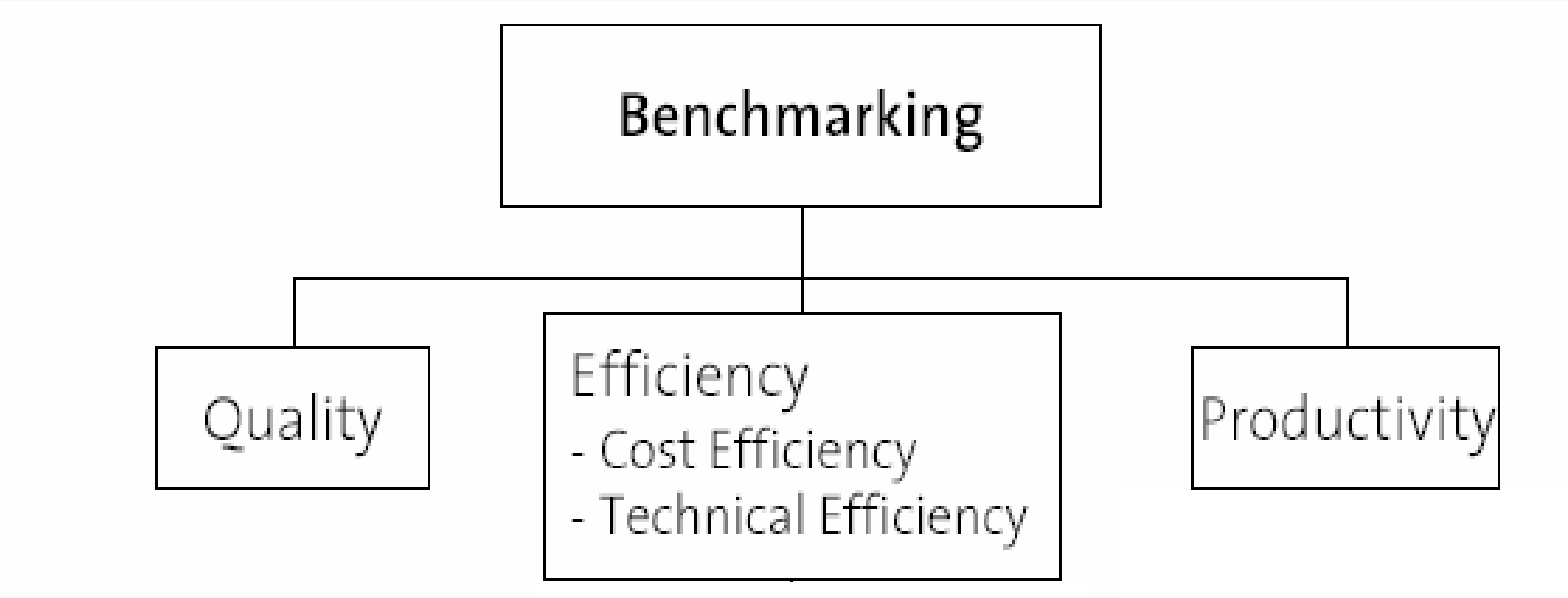
A) Introduction

- Most of the incentive regulation schemes used in practice are based on *benchmarking* that is,

↳ measuring a company's efficiency against a reference performance.



In benchmarking applications the regulator is generally interested in obtaining a measure of firms' efficiency in order to reward (or punish) companies accordingly.

Country	**Regulation Method**	**Ex ante/ ex post**	**Explicit use of benchmarking**
Finland	Expenditure-cap & Rate of Return	Ex post	No
Netherlands	Yardstick	Ex ante	Yes
Norway	Revenue-cap	Ex ante	Yes
Sweden	Yardstick	Ex post	No
United Kingdom	Price-cap	Ex ante	Yes

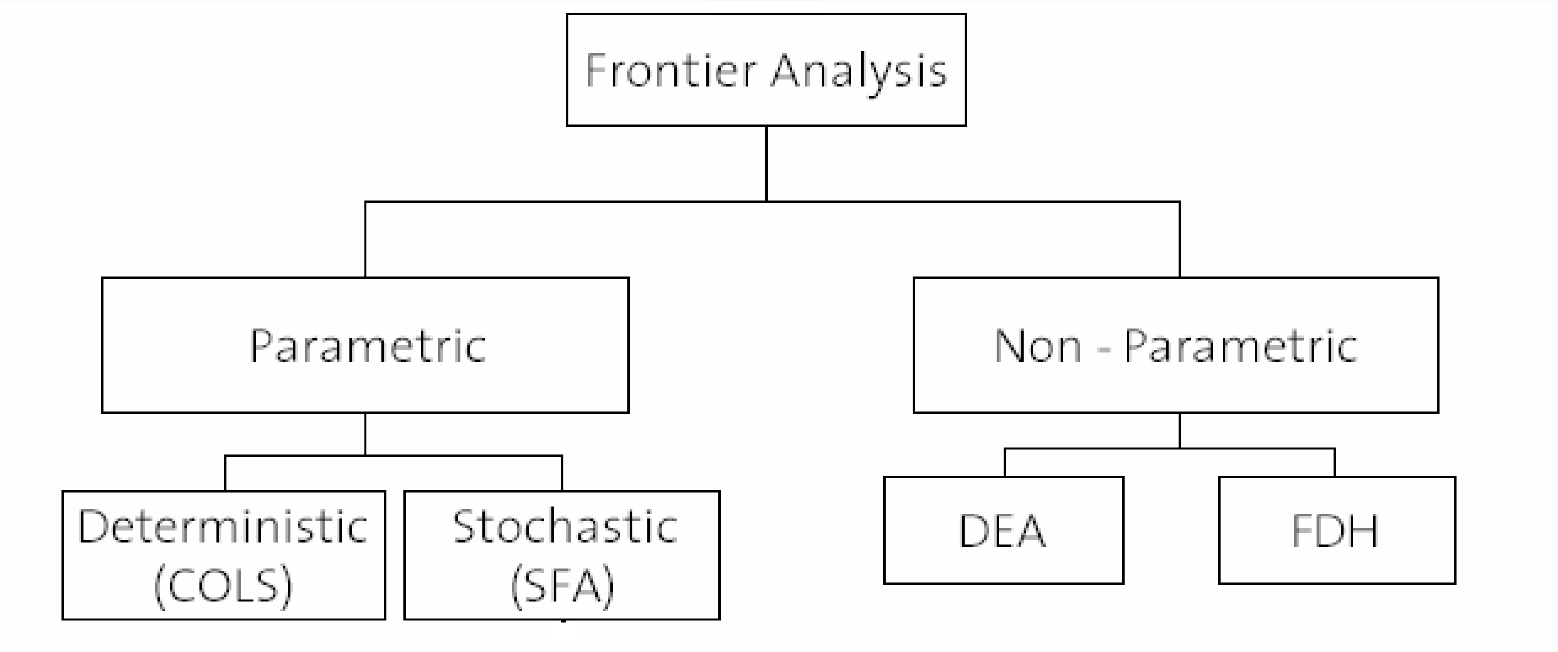
Variety of methods and models

- The reliability of efficiency scores is therefore crucial for an effective implementation of the incentive mechanism.
- There are a wide variety of methods to measure efficiency.
- A main problem faced by regulators is the choice of the benchmarking method and within each method the choice among several legitimate models.

Two approaches

In the literature we can distinguish two principal types of approaches to measure efficiency:

- the *econometric (parametric) approach* and
- the *linear programming (non-parametric)* approach.



Two approaches

- Both approaches – *econometric* and *linear programming* – have their own advocates. At least in the scientific community neither one has emerged as dominant.

- However, it should be noted that the programming approaches have became a popular methodology among electricity regulators.

- The purpose of this presentation is not to stress the advantages and disadvantages of these two different approaches.

DEA: Advantages and Drawbacks

Advantages

- DEA can be implemented on a relatively small dataset,
- Methodology is quick and straightforward to implement using programs that are freely available,
- Inefficient firms are compared to actual firms rather than some statistical measure,
- No assumptions are required about the technology or the specification of the cost / production function,
- Does not assume a functional form for the frontier or a distributional form for the inefficiency term,
- Are easily understandable.

Drawbacks

- May be influenced by noise and outliers,
- Traditional hypothesis testing is not possible,
- The method does not allow for stochastic factors and measurement errors,
- The efficiency scores tend to be sensitive to the choice of input and output variables,
- As more variables are included in the models, the number of firms on the frontier increases.

SFA: Advantages and Drawbacks

Advantages

- Attempts to account for noise,
- Environmental variables are easier to deal with,
- Allows for the conduct of traditional statistical tests of hypothesis,
- Easier to identify outliers,
- Cost frontier and distance function can deal with multiple outputs,
- Allows to control for unobserved heterogeneity.

Drawbacks

- The decomposition of the error term into noise and efficiency component may be affected:
  - ↳ by the particular distributional forms specified and
  - ↳ by the related assumption that error skewness is an indication of inefficiency.
- Requires large sample size for robust estimates, which may not be available,
- Are not easily understandable.

Empirical evidence

- The empirical evidence in the electricity sector suggests that the results in terms of efficiency are sensitive to the approach used.

- Jamasb and Pollit (2003), Estache et al. (2004) , Farsi and Filippini (2004, 2005) show that there are:

↳ substantial variations in estimated efficiency scores and rank orders across different approaches (parametric and non-parametric) and

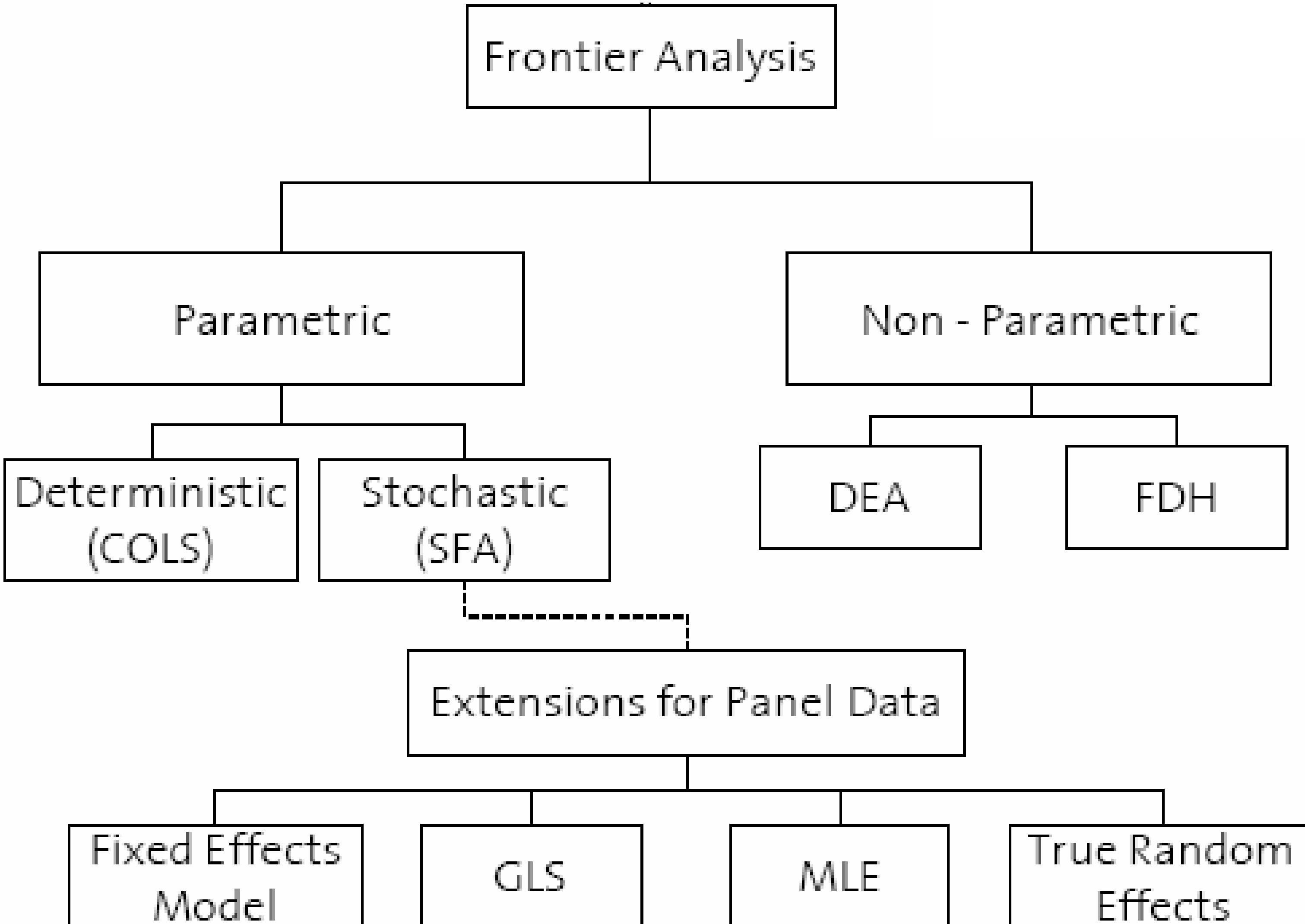
↳ among different econometric models.

Unobserved heterogeneity and goal of the study

- Part of this discrepancy is related to the unobserved heterogeneity across firms namely those related to network characteristics and other external differences that are beyond the firm's control.

- In the context of parametric methods, panel data could be helpful to distinguish efficiency differences from unobserved heterogeneity.

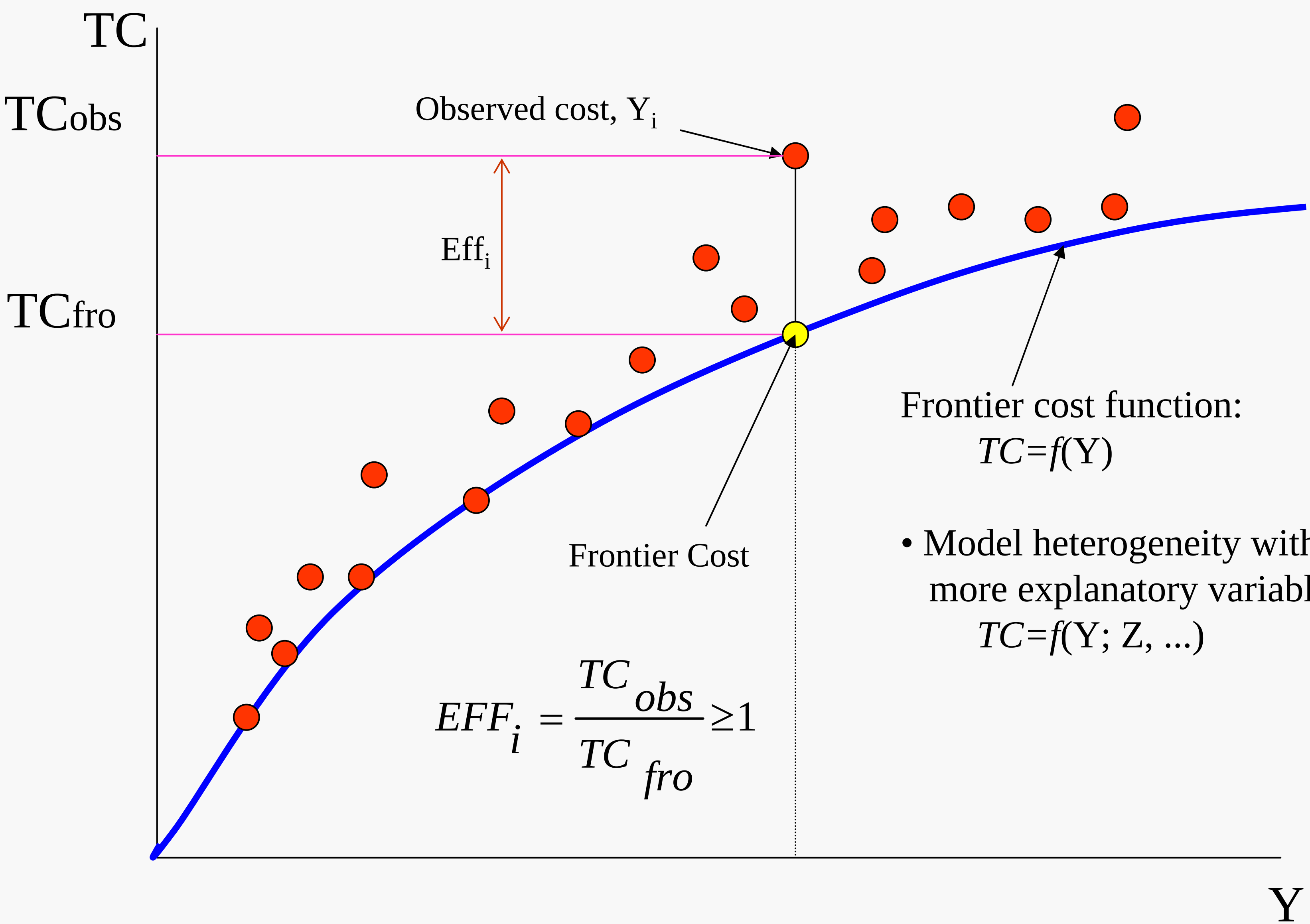
- We are interested to analyze the ability of alternative panel data econometric frontier models to distinguish unobserved firm-specific heterogeneity from inefficiency.



Greene (2005)

Farsi et al. (2004; 2005)

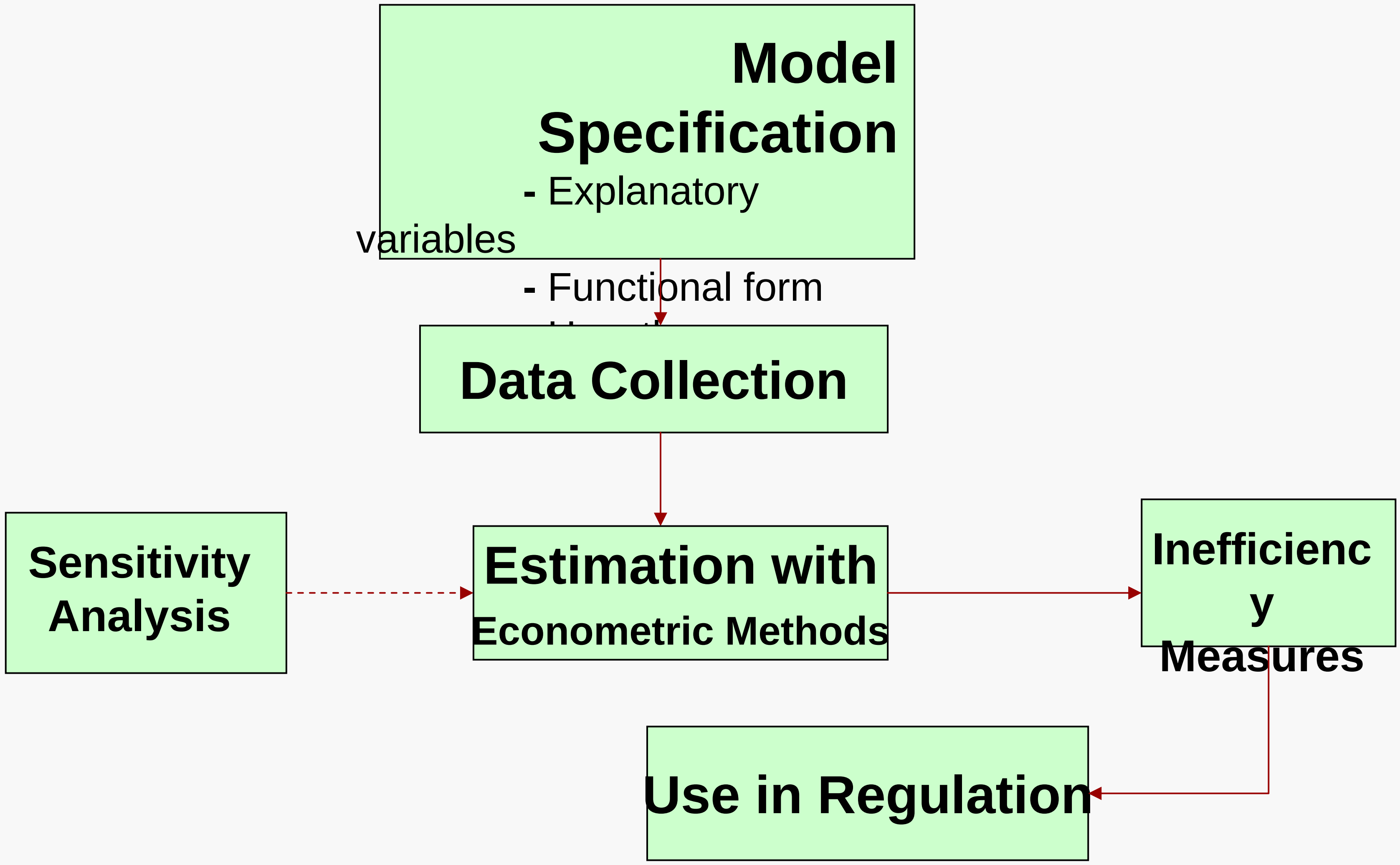
Cost Frontier



$$EFF_i = \frac{TC_{obs}}{TC_{fro}} \geq 1$$

- Model heterogeneity with more explanatory variables: *TC*=*f*(Y; Z, ...)

B) Empirical Analysis



Model Specification

$$C = C(Y, P_K, P_E, P_L, LF, CU, AS, HGRID, DOT)$$

C : Total costs
Y : Output (total number of kWh delivered)
PK,PL,PE: Prices of capital, labor and input power
LF: Load factor
CU: Number of customers
AS: Size of the service area of the distribution utility
HGRID: Indicator for high-voltage transmission network
DOT: Indicator for auxiliary revenues (> 25%)

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Functional form

$$\ln\left(\frac{C}{P_P}\right)_{it} = \beta_0 + \beta_Y \ln Y_{it} + \beta_K \ln\left(\frac{P_K}{P_P}\right)_{it} + \beta_L \ln\left(\frac{P_L}{P_P}\right)_{it} + \gamma_1 \ln LF_{it}$$

$$+\gamma_2 \ln AS_{it} + \gamma_3 \ln CU_{it} + \delta_1 HGRID_{it} + \delta_2 DOT_{it} + r_{it}$$

$$\text{with} \quad i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T_i$$

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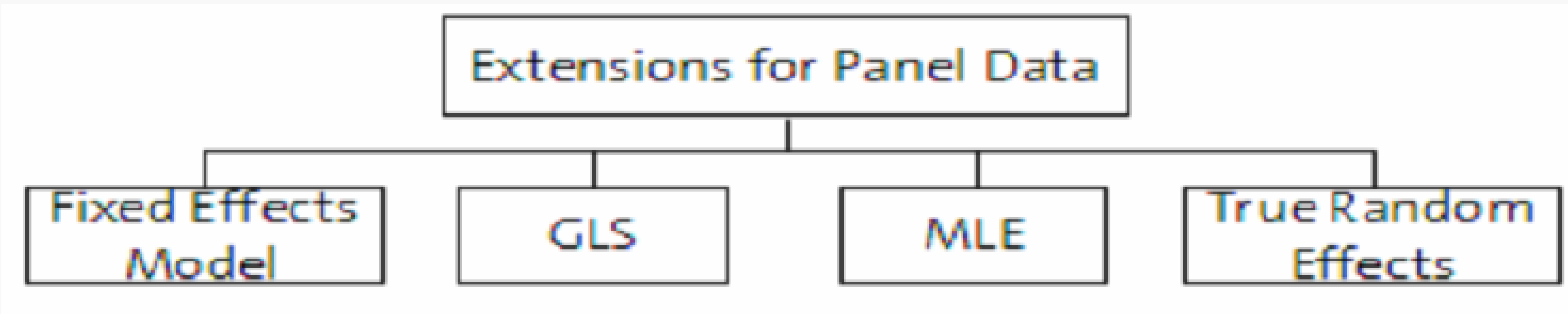
Data

- 59 Swiss electricity distribution utilities
- Period 1988-1996
- => Unbalanced panel with 380 observations
- Data sources:
  - (Unpublished) financial statistics on electric utilities (Swiss Federal Office of Energy)
  - Mail survey
  - Area statistics (Swiss Federal Office of Statistics)

Econometric specifications of the stochastic cost frontier



$$\ln C_{it} = \ln C(y_{it}, w_{it}) + \alpha_i + \varepsilon_{it} \qquad \alpha_i \geq 0$$

No specification of α_i

•Random-effects model

• Fixed-effects model

Particular specification of αi

•Maximum Likelihood

$$\ln C_{it} = \ln C(y_{it}, w_{it}) + \alpha_i + u_{it} + v_{it} \qquad u_{it} \geq 0$$

inefficiency

Individual heterogeneity

Stochastic term

Cost frontier parameters - Panel data

	GLS		MLE		True RE	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
$\ln Y$	.783*	.031	.789*	.037	.754*	.004
$\ln CU$	.150*	.033	.145*	.048	.185*	.004
$\ln AS$	.052*	.009	.046*	.014	.056*	.001
$\ln LF$	-.234*	.038	-.211*	.022	-.155*	.007

- Estimated functions are well behaved.
- All the parameter estimates are statistically significant and have expected signs.
- Some coefficients across the models are similar.

Inefficiency estimates

	GLS	MLE	True RE
Minimum	0.723	0.735	0.861
Maximum	1	0.993	0.996
Average	**0.868**	**0.887**	**0.957**
Median	0.857	0.877	0.966
90 Percentile	0.981	0.99	0.99

Correlation between efficiency ranks (380 obs.)

GLS	1		
MLE	0.970	1	
True RE	0.042	0.055	1

C) Conclusion

- The empirical studies show that:

↳ there are substantial variations in estimated efficiency scores and rank orders across different approaches (parametric and non-parametric) and

↳ among different econometric models.

→Problem for the regulators.

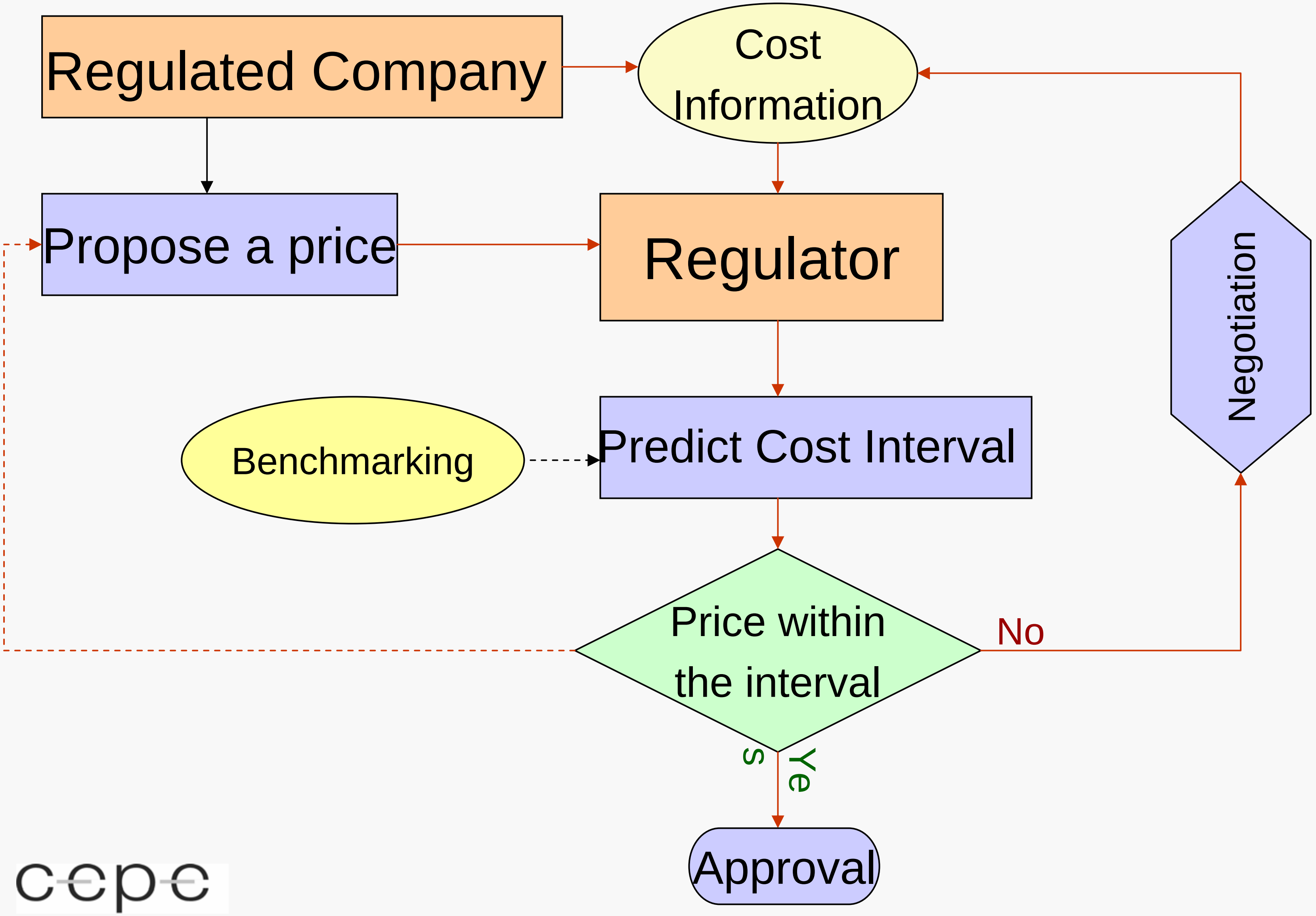
Conclusion

- Part of this discrepancy is related to the unobserved heterogeneity across firms namely those related to network characteristics and other external differences that are beyond the firm's control.
- In this paper we show that in the context of parametric methods, panel data could be helpful to distinguish efficiency differences from unobserved heterogeneity.
- However, the results are not completely satisfactory.

Conclusion

- This paper also proposes an alternative approach to conventional benchmarking that uses panel data models for predicting the expected costs rather than efficiencies.
- This method can be used as an alternative regulation instrument in order to narrow the information gap between the regulator and the regulated companies.
- Generally, we conclude that benchmarking analysis should be used to support rather than to determine regulatory decisions, for instance the value of the price cap.

A possible improvement in the practical application of cost frontier analysis:



THANK YOU
FOR YOUR INTEREST

Implication in an example of price-cap regulation

Price cap: $P_{t+1} = P_t(1 + \Delta CPI - \Delta TFP - X + Z)$

$P_t = 19 \quad \Delta CPI = 1\% \quad \Delta TFP = 1\% \quad Z = 0$

$X =$ Inefficiency Term of regulation $= 5$ years

Company (based on GLS)	Price Cap (Cents)			
	OLS	**RE (GLS)**	**RE (ML)**	**FE**
Median	18.24	18.38	18.43	18.17
Most Efficient	18.71	19.00	18.66	17.45
Least Efficient	17.27	17.54	17.68	17.33
1st Quartile	18.19	18.61	18.52	18.65
3rd Quartile	17.84	18.21	18.29	18.37