Efficiency and Regulation of Electricity and Gas Distribution Companies

How to use efficiency measurement in regulation?

Panel

- **Tooraj Jamasb:**
  Benchmarking and Regulation in Energy Industry: An Overview
- **Einar Hope:**
  Benchmarking and regulation: Pitfalls and issues in electricity regulation
- **Massimo Filippini and Mehdi Farsi:**
  Regulation and Measuring Cost Efficiency with Panel Data Models: Application to Electricity Distribution Utilities

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Regulation and Measuring Cost Efficiency with Panel Data Models: Application to Electricity Distribution Utilities

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Outline

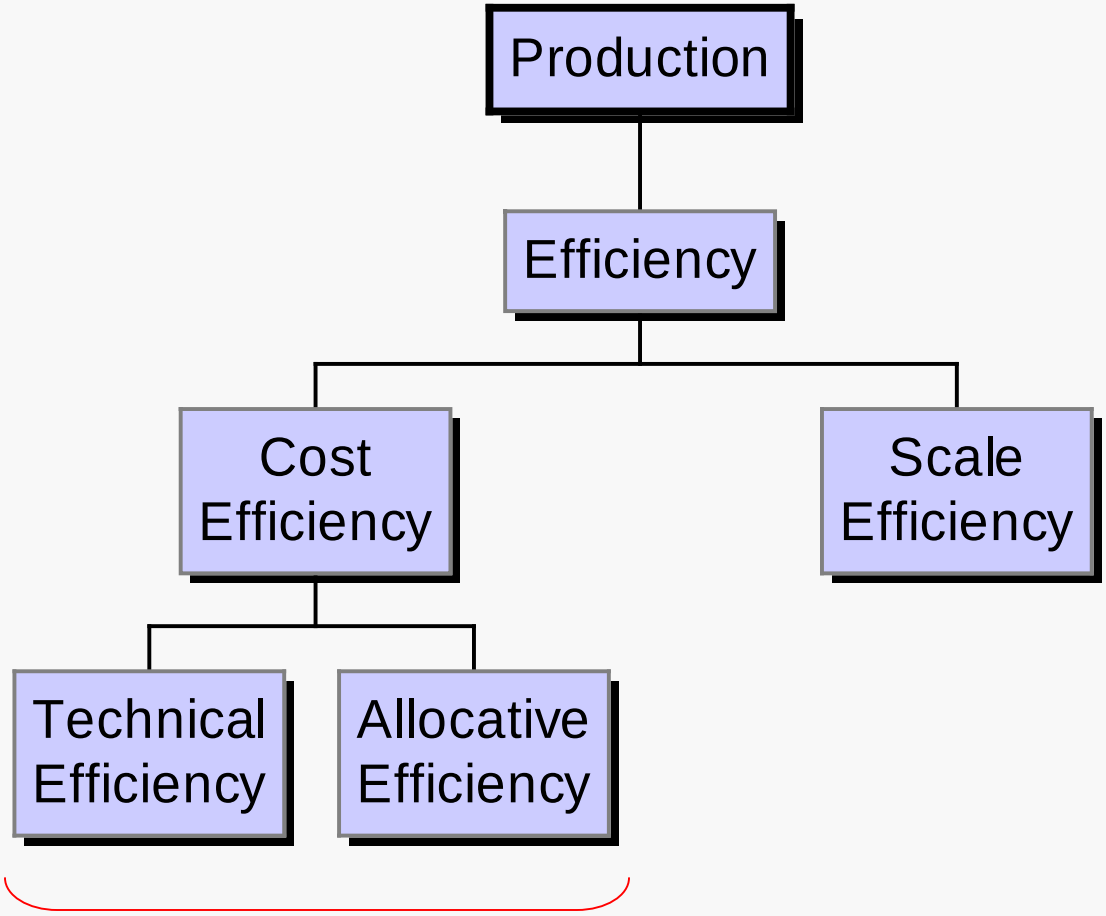
Goals:

- **Estimation of inefficiency scores in electricity distribution utilities using different methods**
- **Study the implications of the empirical results in performance-based regulation**

Contents:

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

Efficiency concept



Inefficiency measurement methods

Simple Indicators

Average cost; Partial productivity indicators; TFP

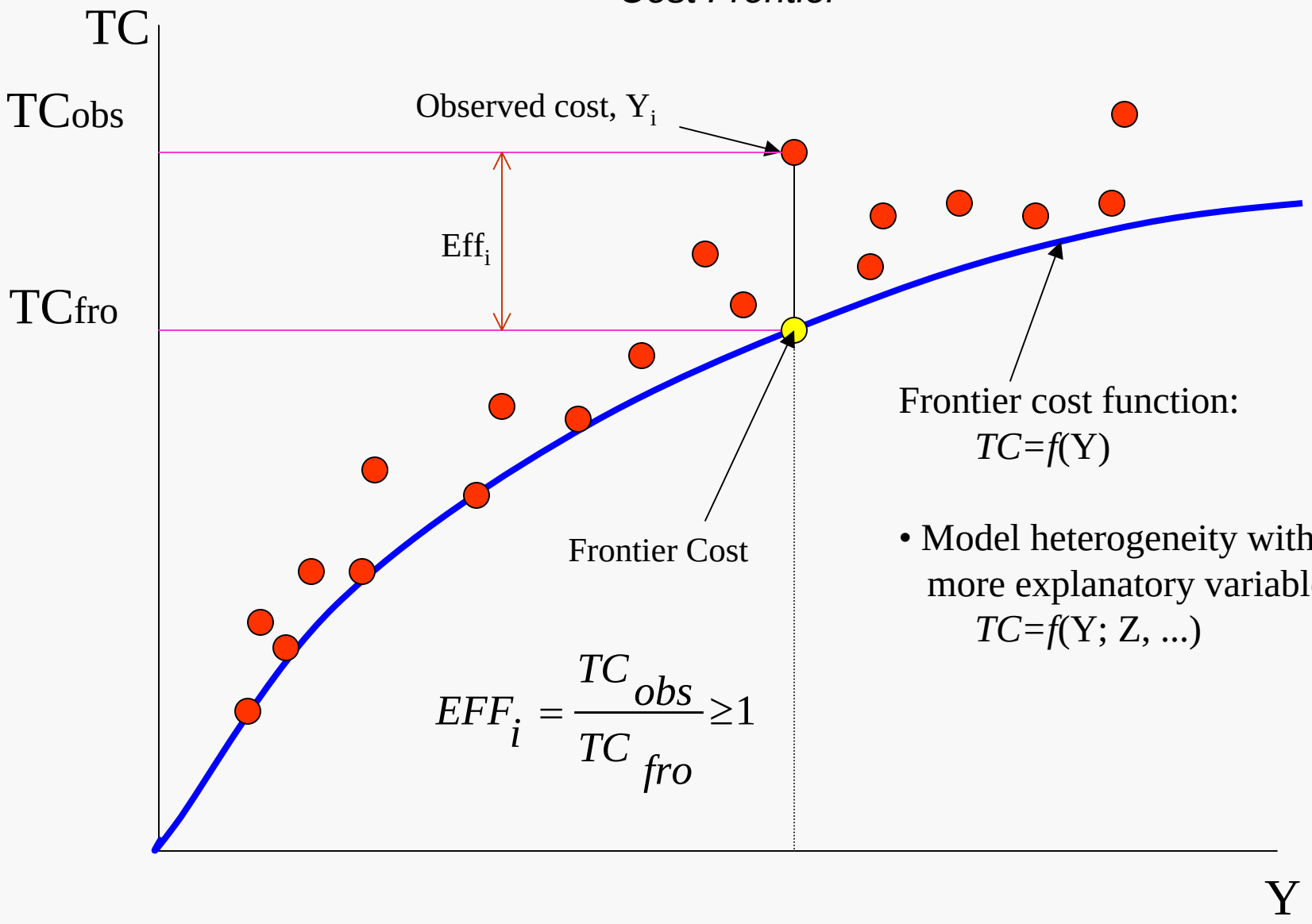
Operations Research

Data Envelopment Analysis; Free Disposal Hull

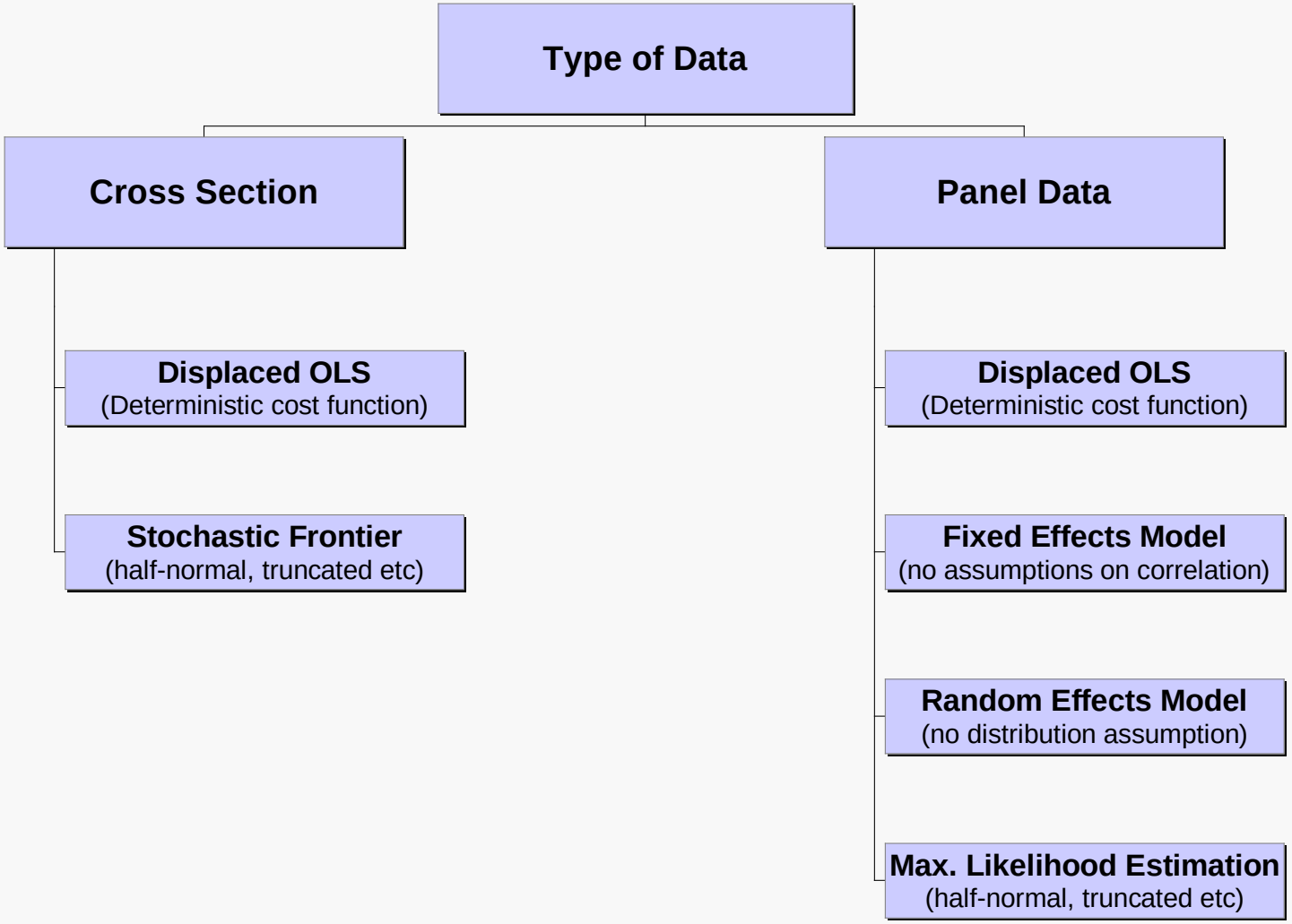
Econometric Approach

Cost Frontier Regression

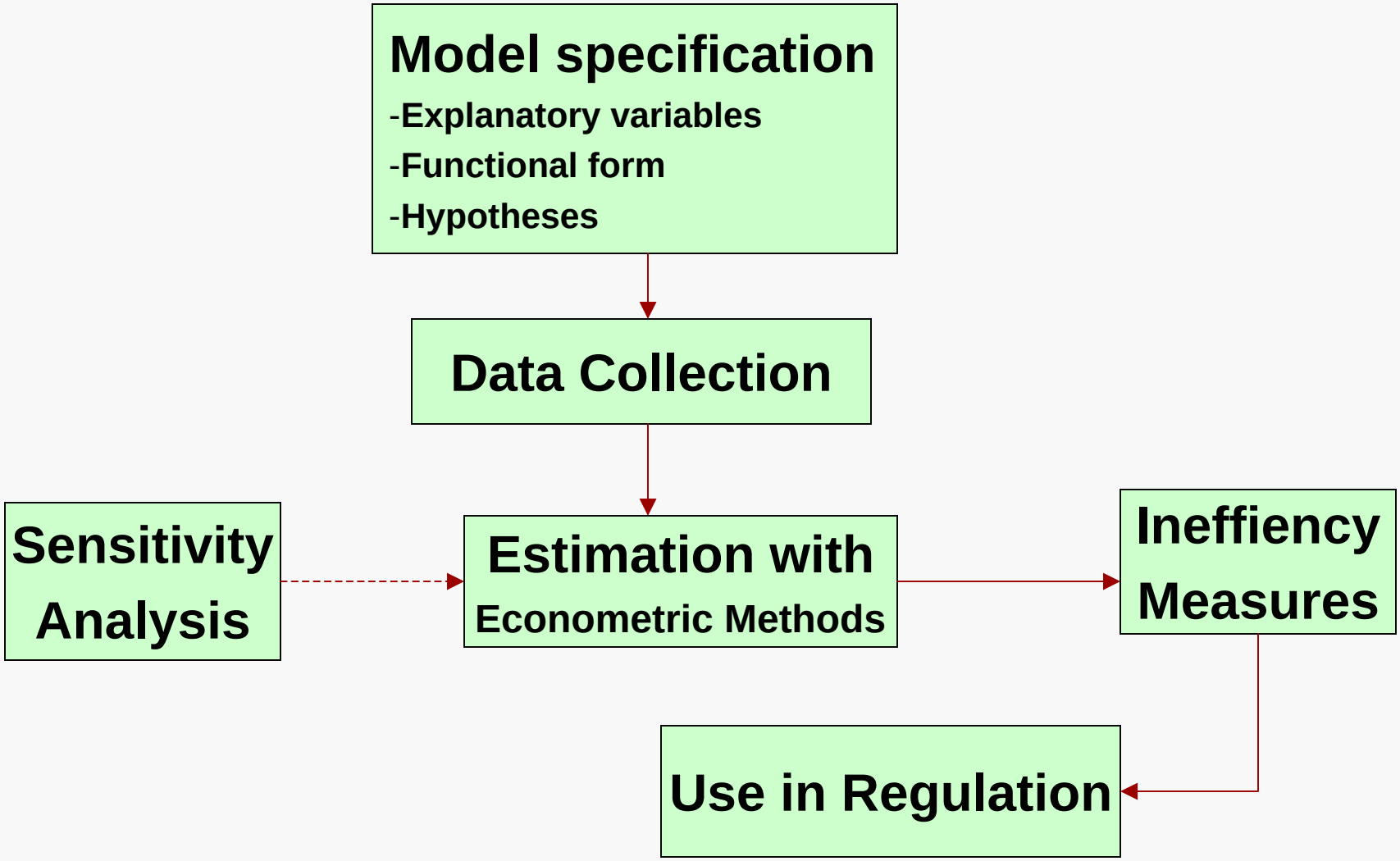
Cost Frontier



Cost Frontier Analysis



Empirical Analysis



Model Specification

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

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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%)
DW: Indicator for forest coverage (>40%)

Problem: definition of the capital price

Functional form

$$\ln\left(\frac{C}{P_P}\right) = \beta_0 + \beta_Y \ln Y + \beta_{AS} \ln AS + \beta_{CU} \ln CU$$

$$+ \beta_{LF} \ln LF + \beta_K \ln\left(\frac{P_K}{P_P}\right) + \beta_L \ln\left(\frac{P_L}{P_P}\right)$$

$$+ \delta_1 HGRID + \delta_2 DOT + \delta_3 DW + \beta_T T$$

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)

Cost efficiency analysis

	OLS	RE (GLS)	RE (MLE)	FE
Minimum	1.07	1	1.07	1
Maximum	1.46	1.38	1.36	2.14
Average	1.23	1.16	1.15	1.35
Median	1.22	1.16	1.13	1.31
95 Percentile	1.41	1.32	1.30	1.66
Number of Firms	59	59	59	59

Correlation between efficiency ranks

	DOLS	RE (GLS)	RE (MLE)	FE
DOLS	1			
RE (GLS)	0.936	1		
RE (MLE)	0.838	0.895	1	
FE	0.447	0.514	0.417	1

Implication for some typical companies

Company	Inefficiency Score			
	OLS	**RE (GLS)**	**RE (ML)**	**FE**
A	1.20	1.16	1.15	1.22
B	1.08	1.00	1.09	1.41
C	1.46	1.38	1.35	1.44
D	1.21	1.10	1.13	1.09
E	1.31	1.21	1.19	1.17

•The companies are adopted based on the ranking obtained from the RE (GLS) model: A: median; B: most efficient; C: least efficient; D: 1st quartile; E: 3rd quartile .

Problems in application of efficiency indicators in regulation:

- From an econometric point of view it is not straightforward to specify which model is the best one.
- Only after a careful econometric analysis the efficiency indicators can be used in regualtion.
- We should be careful in using directly the level of inefficiency scores in regulation, for instance in a price cap regulation formula.

Conclusions

- The estimated frontier cost function can be a useful instrument for yardstick and price cap regulation.
- Advantages: Heterogeneity factors can be incorporated in setting yardstick and price cap regulation (fair benchmarking).
- The regualtor and firms should be aware that the results can be influenced by the model specification, functional form and the econometric approach.
- The use of intervals instead of point estimators for efficiency indicators could be a possible improvement.

THANK YOU
FOR YOUR INTEREST

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Regression Results

	OLS		Random-Effects (GLS)		Random-Effects (MLE)		Fixed-Effects	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
lnY	0.851	0.017	0.78	0.032	0.767	0.04	0.677	0.055
lnCU	0.084	0.017	0.153	0.033	0.163	0.048	0.251	0.096
lnAS	0.044	0.004	0.051	0.009	0.047	0.013	-	-
lnLF	-0.243	0.037	-0.239	0.039	-0.23	0.023	-0.213	0.044
lnPL	0.067	0.011	0.041	0.014	0.039	0.014	0.038	0.016
lnPK	0.2	0.009	0.174	0.01	0.171	0.005	0.169	0.01
HGRID	0.063	0.012	0.075	0.027	0.098	0.039	-	-
DOT	0.033	0.01	0.05	0.022	0.04	0.028	-	-
DW	0.014	0.01	0.012	0.023	0.062	0.028	-	-
T	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002
Constant	-2.236	0.233	-0.793	0.369	-0.653	0.43	-	-

- Estimated functions are well behaved.
- Almost all the parameter estimates are statistically highly significant and have the expected sign.
- Some coefficients across the models are similar.

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Implication in an example of price-cap regulation

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

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

$X = \text{Inefficiency} \quad \text{Term of regulation} = 5 \text{ years}$

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

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Prediction errors

Type of prediction	Out-of-sample			1-year-ahead		
Model	OLS	RE	FE	OLS	RE	FE
Average absolute error	7.37	7.57	11.8	5.91	3.02	3.1
Maximum absolute error	25.2	27.3	39	17	10.3	10.3
95 percentile absolute error	17.8	20.1	31.1	13.5	6.82	7.66
Average prediction bias	0.34	0.98	1.08	-0.03	0.08	0.24
Number of predictions	380	380	380	52	52	52

- Errors are given in percentage of the actual costs.

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Stochastic Frontier Model with Panel Data

$$OLS: \quad \ln C_{it} = \ln C(y_{it}, w_{it}) + v_{it} \qquad v_{it} \sim iid(0, \sigma_v^2)$$

$$Deterministic: \quad \ln C_{it} = \ln C(y_{it}, w_{it}) + u_{it} \qquad u_{it} \geq 0$$

$$Stochastic: \quad \ln C_{it} = \ln C(y_{it}, w_{it}) + u_i + v_{it} \qquad u_i \geq 0$$

Different Specifications of u_i :
- *half-normal, truncated, ...*
- **Maximum Likelihood**

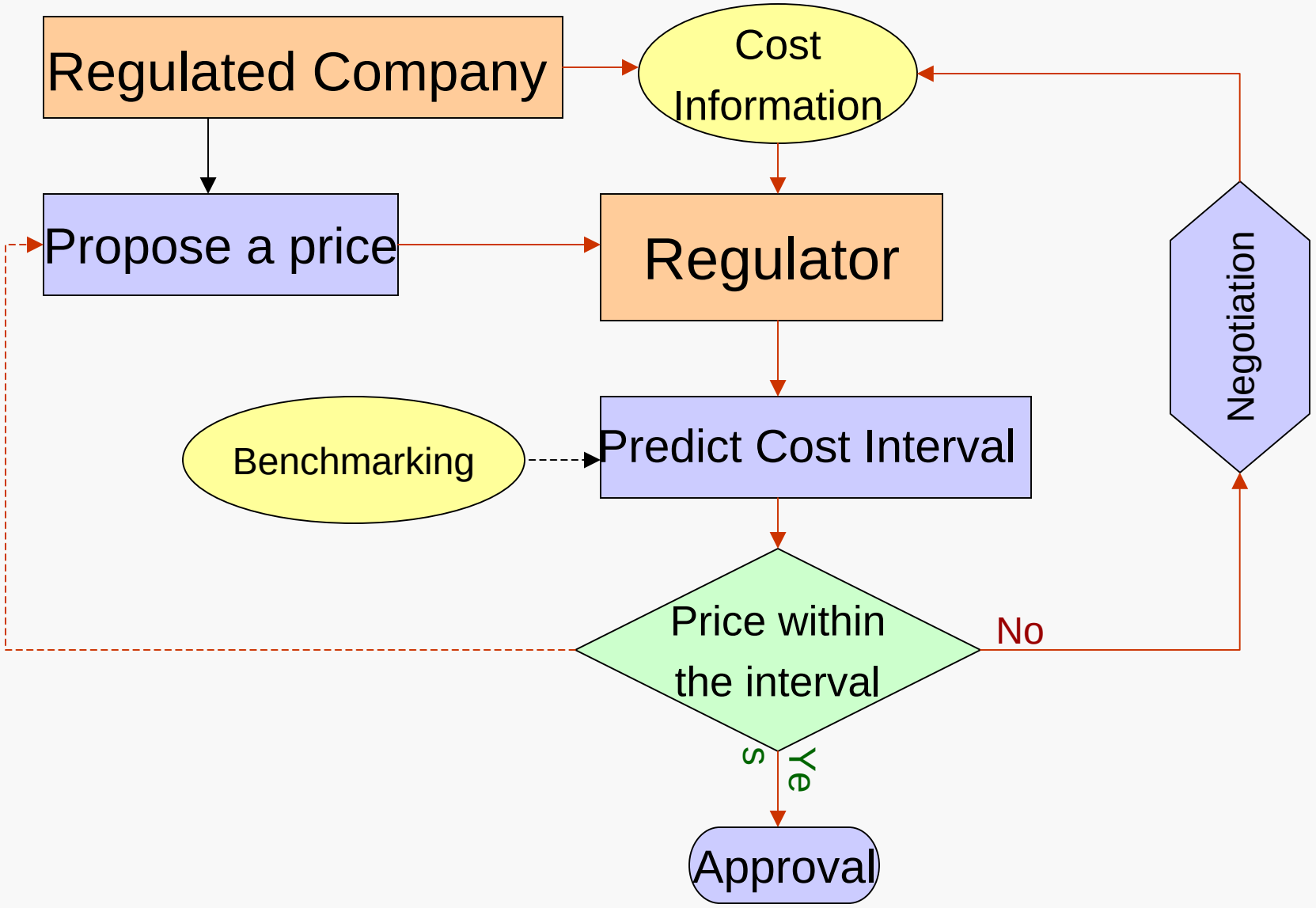
No particular specification of u_i with Panel Data:
- **Random-effects model**
- **Fixed-effects model**

Effect of outputs and output characteristics on total costs

	OLS	RE (GLS)	RE (MLE)	FE
lnY	0.851	0.78	0.767	0.677
lnCU	0.084	0.153	0.163	0.251
lnAS	0.044	0.051	0.047	-
lnLF	-0.243	-0.239	-0.23	-0.213

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

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



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