EFFICIENCY AND REGULATION OF THE SLOVENIAN WATER DISTRIBUTION UTILITIES

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Objective of the study

- Estimation of the cost frontier function in order to obtain:
    - cost inefficiency estimates
    - estimates of economies of scale and density
- Analyse how separation of unobserved heterogeneity from inefficiency influences the results
- Implications of the obtained results for price regulation

Outline

1. Incentive-based price regulation
2. Review of the relevant studies
3. Model specification and methodology
4. Data description
5. Estimation results
6. Conclusions

1. Incentive-based price regulation

- Objective: to improve efficiency of regulated firms
- Use of benchmarking: to overcome infromational asymmetry problem between the regulator and firms
- Best practice approaches in the EU water industry:
  - The UK regulator OFGEM: price-cap (RPI-X) regulation combined with benchmarking
  - Italian Regulatory Authority: rate-of-return regulation combined with benchmarking

1. Price-regulation of Slovenian water industry

- Current regulation resembles **rate-of-return regulation**
- Very restrictive limits for **max. price increases** set
- **Prices** typically **do not cover full costs**
- Proposal to use **benchmarking** but not yet put into practice

- This study considers the use of **Stochastic Frontier Benchmarking Methods**

1. Empirical evidence

- The empirical evidence 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 (2006) 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

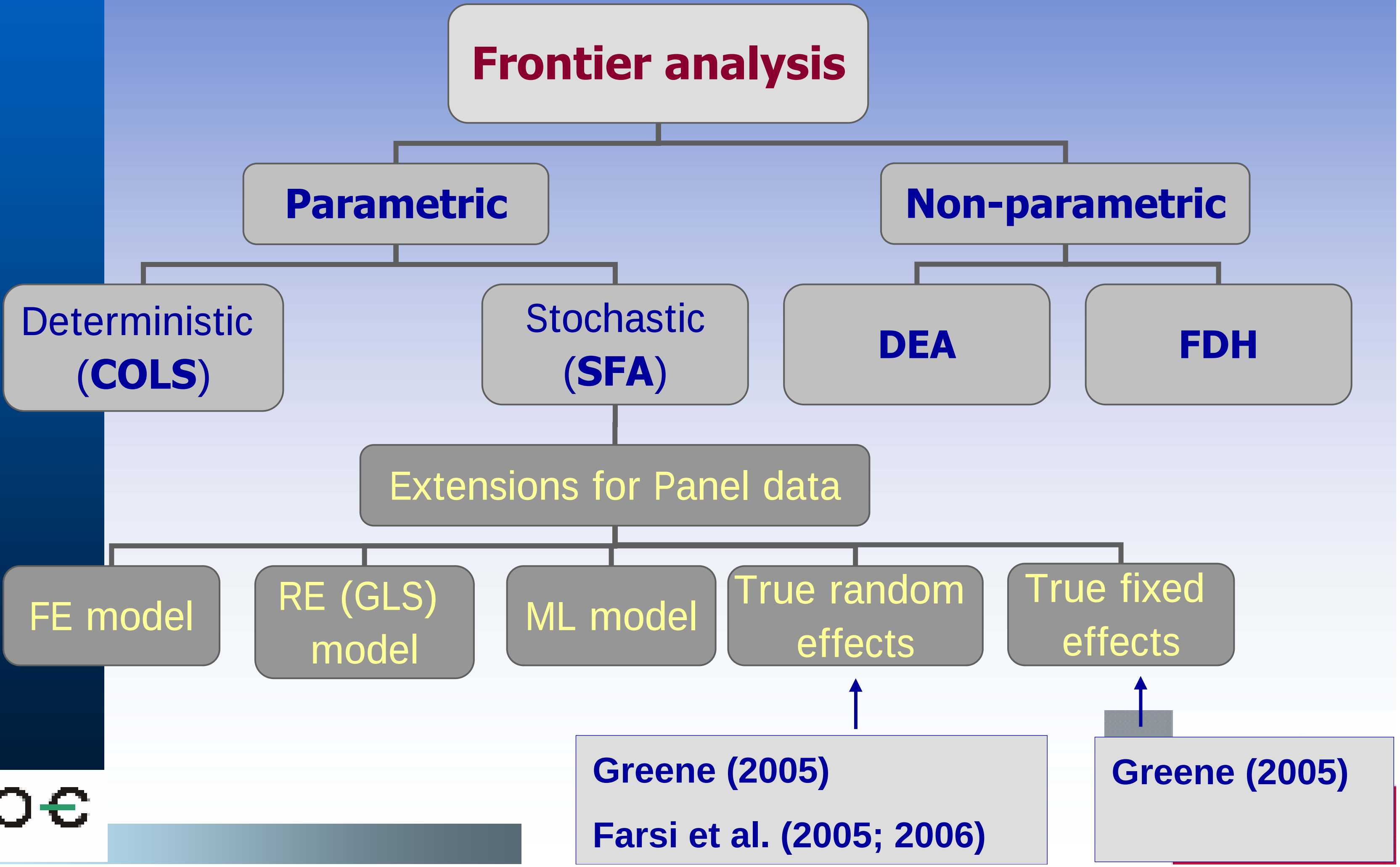
1. Unobserved heterogeneity and goal of the study

- Part of this discrepancy is related to the unobserved heterogeneity across firms 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

1. Frontier benchmarking methods



- **Frontier analysis**
  - **Parametric**
    - Deterministic (**COLS**)
    - Stochastic (**SFA**)
      - Extensions for Panel data
        - FE model
        - RE (GLS) model
        - ML model
        - True random effects
        - True fixed effects
  - **Non-parametric**
    - **DEA**
    - **FDH**

Greene (2005)

Farsi et al. (2005; 2006)

Greene (2005)

2. Literature review of relevant studies

Author(s) of the paper	Data sample	Model and functional form	Estimated economies of scale	Estimated economies of density	Estimated cost efficiency
Kim and Clark (1988)	60 US water utilities in 1973	Translog multi-product TC function	0.992 (sample average)[1]	/	/
Bhattacharyya et al. (1995)	221 US water utilities from 1992 survey	Translog VC function	/	1.246 (E_{OD}, private, SR); 0.932 (E_{OD}, public, SR);[2] sample average	0.901 (average; public more efficient)
Antonioli and Filippini (2001)	32 Italian water utilities between 1991-1995	Log-log VC function	0.95 (LR)	1.46 (E_{OD}, LR) 1.16 (E_{CD}, LR)	/
Mizutani and Urakami (2001)	112 Japanese water companies in 1994	Log-log, translog TC (general and hedonic) f.	0.921 (sample average)	1.103 (E_{OD}, sample average)	/
Garcia and Thomas (2001)	55 French water utilities between 1995-1997	Multi-product translog VC function	1.002 (sample average, LR)	1.21(E_{OD}, LR); 0.87 (E_{CD}, LR);[3] sample average	/

3. Model specification and methodology

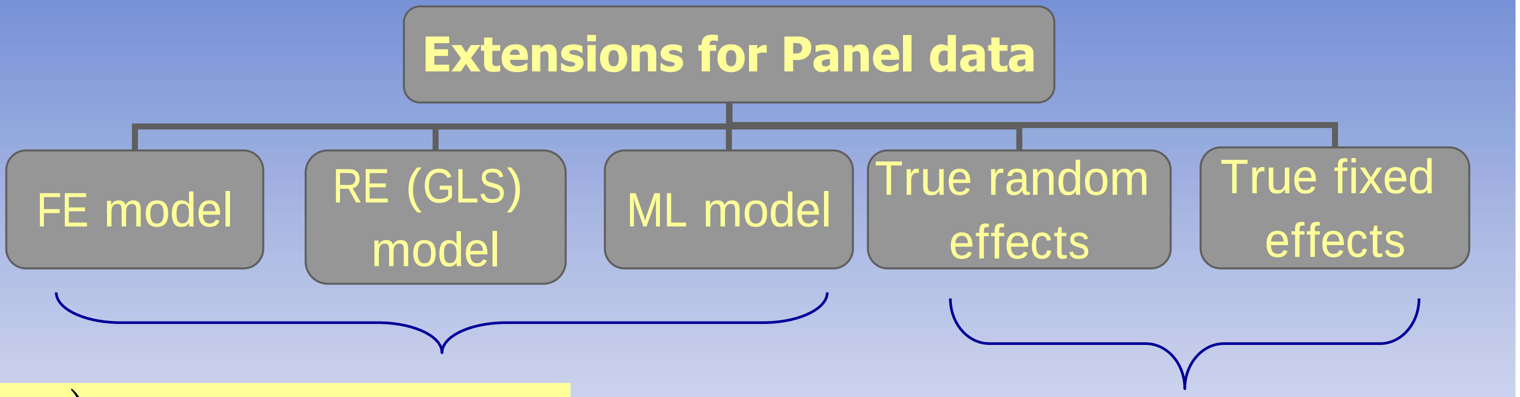
- Specification of the cost function:

$$C = C(Q, P_L, P_M, P_K, CU, AS, D_{LOSL}, D_{TREAT}, D_S, D_U, T)$$

C – total cost (10^3 SIT)
Q – output (total cubic metres of water delivered)
CU – number of customers served
AS – size of the service area
PL, PM, PK – price of labour, material and capital
DLOSL – dummy variable for water losses
DTREAT – dummy for water treatment
DS – dummy for the use of surface water only
DU – dummy variable for underground water only
T – time variable (technical change)

- Translog functional form employed

3. Econometric specifications of the stochastic cost frontier


Extensions for Panel data

FE model

RE (GLS) model

ML model

True random effects

True fixed effects

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

No specification of α_i

- **RE model**
- **FE model**

Distributional assumption on α_i

- **Maximum Likelihood**

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

Individual heterogeneity

inefficiency

stochastic term

3. Model specification and methodology

- Stochastic frontier methods employed

Model	Firm-specific component α_i	Random error ε_{it}	Inefficiency u_{it}
Model I **Pooled (ML)**	None	$\varepsilon_{it} = v_{it} + u_{it}$ $u_{it} \sim \text{iid}\, N^{+}(0, \sigma_u^2)$ $v_{it} \sim \text{iid}\, N(0, \sigma_v^2)$	$E(u_{it} \mid \varepsilon_{it})$
Model II **RE (GLS)**	$\alpha_i \sim \text{iid}(0, \sigma_\alpha^2)$	$\varepsilon_{it} = v_{it} + \alpha_i$ $\text{iid}(0, \sigma_\varepsilon^2)$	$u_i = \hat{\alpha}_i - \min_i \{\hat{\alpha}_i\}$
Model III **RE (ML)**	$u_i \sim \text{iid}\, N^{+}(0, \sigma_u^2)$	$\varepsilon_{it} = v_{it} + u_i$ $v_{it} \sim \text{iid}\, N(0, \sigma_v^2)$	$E(u_i \mid \boldsymbol{\varepsilon}_i)$
Model IV **TFE (ML)**	Fixed (group dummies α_i)	$\varepsilon_{it} = v_{it} + u_{it}$ $u_{it} \sim \text{iid}\, N^{+}(0, \sigma_u^2)$ $v_{it} \sim \text{iid}\, N(0, \sigma_v^2)$	$E(u_{it} \mid \varepsilon_{it})$

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3. Model specification and methodology

- Economies of output density (E_{OD})

$$E_{OD} = \left(\frac{\partial \ln C}{\partial \ln Q} \right)^{-1}$$

- Economies of customer density (E_{CD})

$$E_{CD} = \left(\frac{\partial \ln C}{\partial \ln Q} + \frac{\partial \ln C}{\partial \ln CU} \right)^{-1}$$

- Economies of scale (E_S)

$$E_S = \left(\frac{\partial \ln C}{\partial \ln Q} + \frac{\partial \ln C}{\partial \ln CU} + \frac{\partial \ln C}{\partial \ln AS} \right)^{-1}$$

4. Data

- Slovenian water supply: part of the communal sector, obligatory local public service
- **Data collected via a questionnaire** issued by the Ministry of the Environment and Spatial Planning
- **Panel data set** consisting of 52 water supply utilities in Slovenia over the 1997-2003 period
- Data refer to the **supply of drinking water only**
- Utilities in the sample supply 153 municipalities in Slovenia (around 80% of all municipalities)

5. RESULTS

- Cost inefficiency:

$$CE_{it} = \frac{C_{it}^{*}}{C_{it}} = \exp(-u_{it}) \;\geq\; 1$$

- Cost inefficiency estimates

Inefficiency score (*EFF$_i$*)	Model I Pooled (ML)	Model II RE (GLS)	Model III RE (ML)	Model IV TFE (ML)
Mean	1,225	1,663	1,500	1,191
Median	1,181	1,556	1,378	1,182
Std. Dev.	0,162	0,376	0,346	0,057
Minimum	1,031	1,000	1,118	1,067
Maximum	1,710	2,690	2,599	1,514

5. RESULTS

- Correlation between inefficiency scores

R	Model I Pooled (ML)	Model II RE (GLS)	Model III RE (ML)	Model IV TFE (ML)
Model I	1	0,667*	0,614*	0,399*
Model II		1	0,932*	0,023
Model III			1	0,027
Model IV				1

Note: * – significant at 0.1% (two-sided significance level)

5. RESULTS

- Estimated economies of scale and density

Econonomies	Quartile	*Model I* Pooled (ML)	*Model II* RE (GLS)	*Model III* RE (ML)	*Model IV* TFE (ML)
E_{OD}	1st Quartile	3,099	3,485	3,500	4,605
	Median	3,042	3,455	3,448	3,874
	3rd Quartile	1,846	2,509	2,689	2,029
E_{CD}	1st Quartile	1,214	1,222	1,277	1,109
	Median	1,286	1,316	1,344	1,313
	3rd Quartile	1,182	1,265	1,263	1,208
E_S	1st Quartile	1,289	1,121	1,157	1,311
	Median	1,030	1,040	1,039	1,088
	3rd Quartile	0,816	0,933	0,925	0,846

6. Conclusions

- Two possible sources of cost savings in the Slovenian water industry recognized:
    - improving on scale efficiency
    - improving on cost efficiency
- Inefficiency results influenced by different ability of the models to distinguish between unobserved heterogeneity and inefficiency
- In price regulation results from SFA should be used with caution and not in a mechanical way
- Different models fairly consistent in estimating economies of scale and density