RECOCA
Municipal Waste Water Treatment – Costs, and Efficiency

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Dataset

- Goal – efficiency and costs of WWTP as a means of reducing N and P loads to the Baltic Sea
- Dataset
  - 1237 surveys of WWTP operators in Poland
  - Total capacity of 1282 hm^3 vs. 1580 hm^3 of water sold to households (81%)

General indicators

	Primary	Secondary	Tertiary	All
No. of plants	70	720	324	1114
Capacity $\left[m^3 \cdot \text{year}^{-1} \cdot 10^3\right]$				
Median	50.00	78.70	680.60	110.50
Mean	158.47	342.83	2 365.46	919.51
0.05 percentile	5.90	7.80	31.53	10.00
0.95 percentile	869.70	1 162.95	8 733.13	3 606.05
Standard deviation	282.50	1 417.13	6 790.99	3 942.86
Unit cost $\left[\text{PLN} \cdot m^{-3}\right]$				
Median	3.23	2.90	2.44	2.72
Mean	3.55	3.66	2.94	3.44
Weighted average	2.57	2.21	2.06	2.10
0.05 percentile	1.34	1.04	1.09	1.05
0.95 percentile	7.48	8.83	6.37	8.12
Standard deviation	2.05	3.06	2.15	2.79

Controlling for plants' capacity

- Increasing returns to scale
  - Highly non-linear relationship
  - Box-Cox regression model

$$UC^{(\theta)} = \boldsymbol{\alpha}'\mathbf{z} + \beta \cdot size^{(\lambda)}$$

- where:

$$x^{(\alpha)} = \begin{cases} \dfrac{x^{\alpha} - 1}{\alpha} & \text{for} \quad \alpha \neq 0 \\ \ln x & \text{for} \quad \alpha = 0 \end{cases}$$

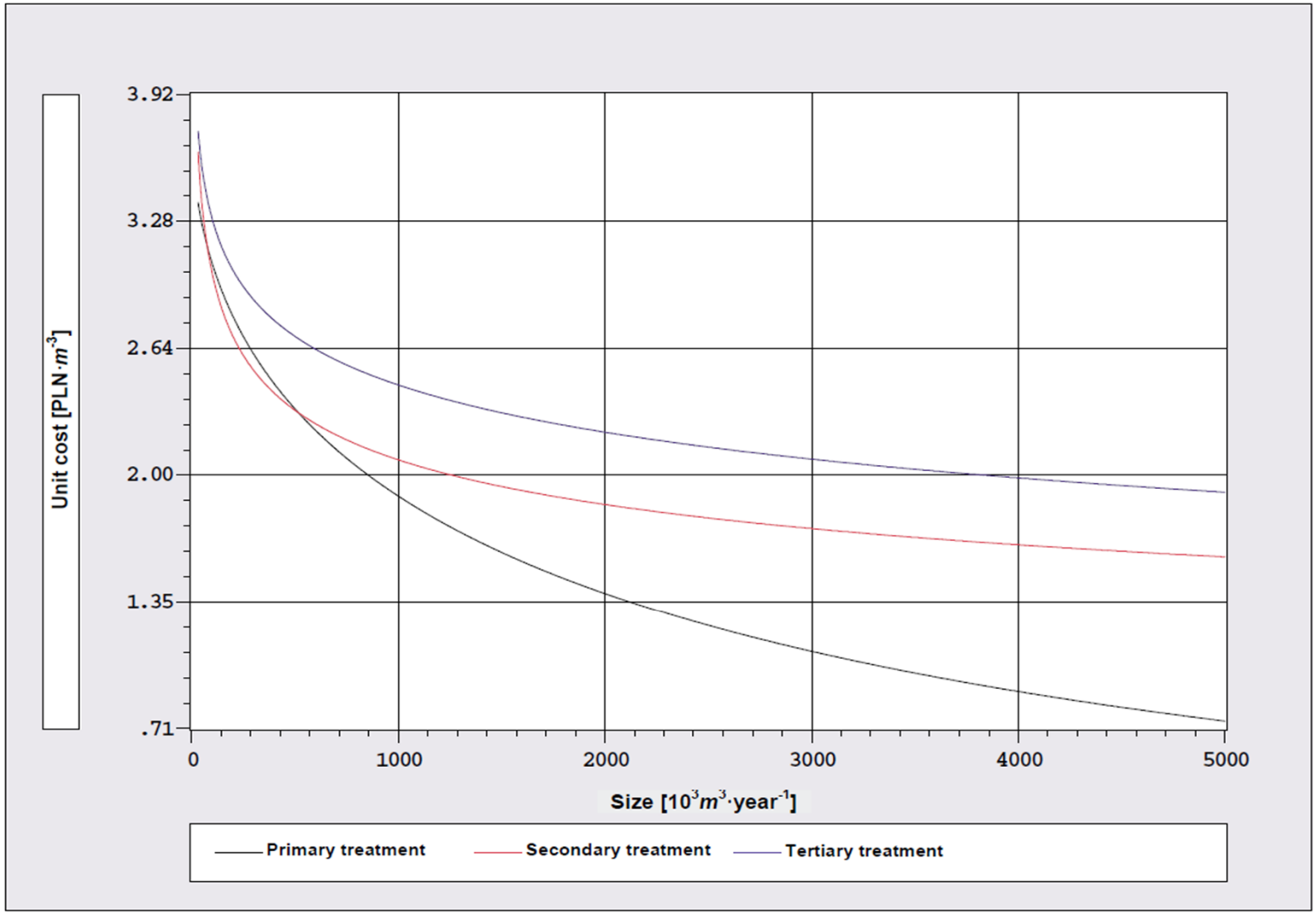
- Then:

$$UC = \left[\theta \left(\alpha + \beta \cdot \frac{size^{\lambda} - 1}{\lambda} \right) + 1 \right]^{\frac{1}{\theta}}$$

The results – unit cost of treatment and collection

Parameters:	primary	secondary	tertiary
α – intercept (parameter)	0.64864*** (0.20963)	0.84182*** (0.08844)	1.05617*** (0.05711)
β – capacity (parameter)	-0.37553 (0.24469)	-0.21940*** (0.05512)	-0.19632*** (0.02795)
θ – theta (transformation parameter)	0.06097 (0.17843)	0.38638*** (0.02084)	0.35604*** (0.03173)
λ – lambda (transformation parameter)	0.50727 (0.33235)	-0.04710 (0.09102)	0.05106 (0.08950)
Adjusted R^2	0.92670	0.87388	0.86363
$F[1, n-2]$ (probability in parentheses)	846.5 (0.0000)	4967.1 (0.0000)	2031.9 (0.0000)
$\chi^2[1]$ (probability in parentheses)	180.9 (0.0000)	1488.8 (0.0000)	643.5 (0.0000)
Capacity elasticity of unit cost (at mean size in the sample)	-0.13825	-0.16269	-0.15606

The results – unit cost of treatment and collection



The results – unit cost of treatment and collection

- Unit cost of treatment and collection in Poland

Capacity $\left[m^3 \cdot \text{year}^{-1}\right]$	**Unit cost** $\left[\text{PLN} \cdot m^{-3}\right]$		
	Primary	Secondary	Tertiary
150 000	2.57	2.82	3.14
1 000 000	(1.89)	2.07	2.45

- Additionally – cost of connection (on-going work)
  - Connecting to sewage system
  - Septic tanks

Efficiency of nutrient removal in WWTP

- Efficiency of nutrient removal (%):

	primary	secondary	tertiary	
Nog	10 (10-20)	55	85	> 100 000 PE
			80	15-100 000 PE
Pog	15 (5-15)	50	90	> 100 000 PE
			85	15-100 000 PE

  - Based on a sample of 205 WWTP in Poland

- To do:
  - Connection costs
  - Compare results, prepare guidelines for other countries