Efficiency of Hospitals in the Czech Republic

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Motivation

Research Questions:

1. How efficient are Czech hospitals with and without determinants?
2. Which exogenous environmental factors influence efficiency and what effect do they have?
3. How much do individual efficiencies differ in terms of rankings with and without determinants.

Outline

1. Motivation and Background
2. Theoretical Model – Stochastic Frontier Analysis
3. Data
   - cost function variables
   - determinants of inefficiency
4. Empirical Results
   - Baseline Model
   - Model with Determinants
5. Discussion
6. Robustness Check
7. Conclusions

Efficiency Measurements & Frontier Methods

Find the maximum amount of output which can be obtained from a given set of input

Efficiency Measurements:

1.
   - technical efficiency
   - allocative efficiency
   - overall economic efficiency

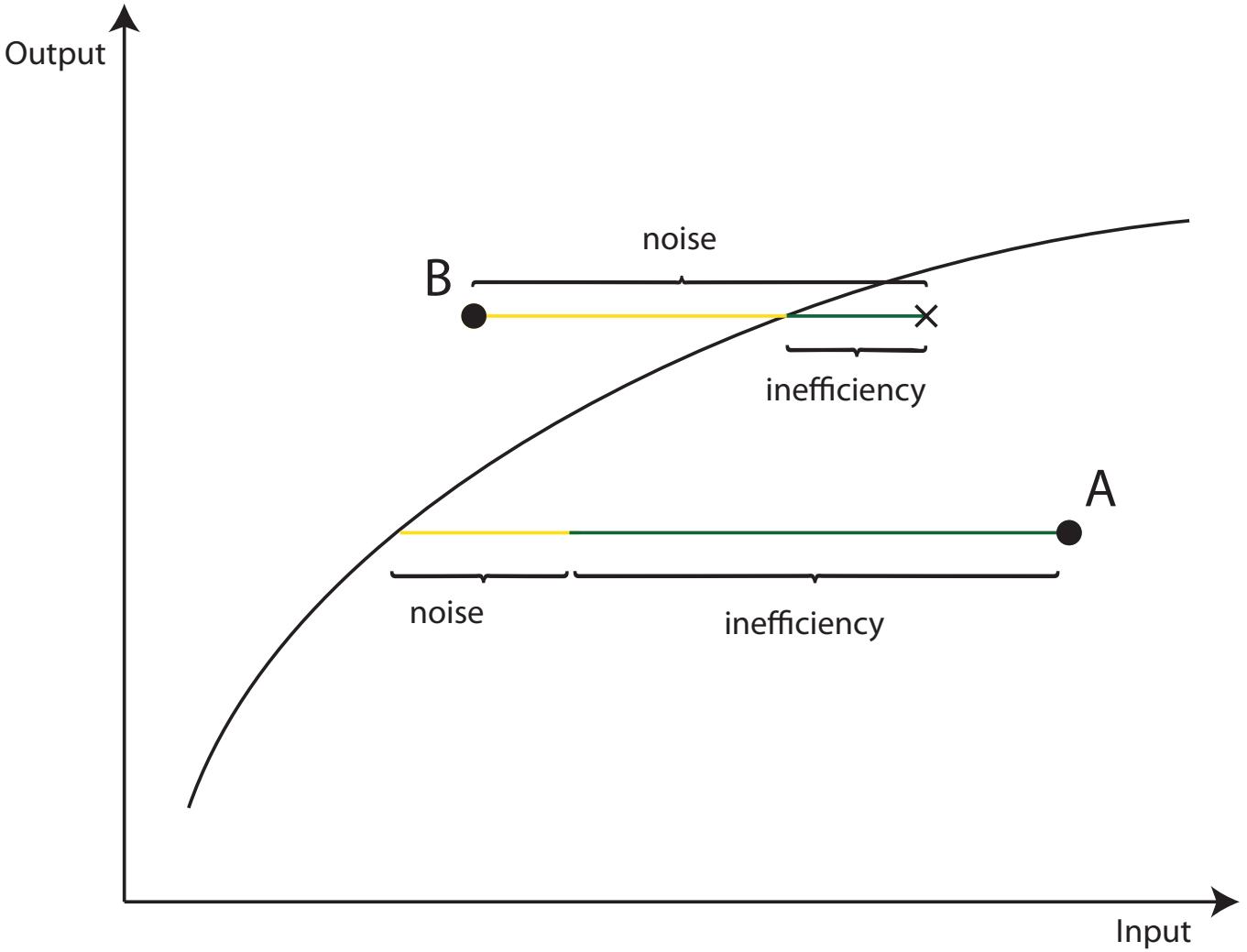
2.
   - input–oriented
   - output–oriented

Frontier Methods:

1.
   - parametric
   - non–parametric

2.
   - deterministic
   - stochastic

Stochastic Frontier Analysis



Theoretical Model

Cobb-Dougals Cost Function:

$$\ln c_{it} = \beta_0 + \sum_{s=1}^{S} \beta_s \ln y_{it}^s + \sum_{m=1}^{M} \beta_m \ln w_{it}^m, \qquad (1)$$

c_{it} ... total costs for DMU_i, $i \in N$, $N = (1, \ldots, n)$, at time $t \in T$

$(y^1, \ldots, y^s)$ ... output variables
$(w^1, \ldots, w^m)$ ... input prices

Theoretical Model

Basic Model (Battese & Coelli, 1992):

$$c_{it} = f(\mathbf{y}_{it}, \mathbf{w}_{it}, \beta) + v_{it} + u_{it} \tag{2}$$

β ... vector of parameters
v_{it} ... random variable assumed to be i.i.d., $v_{it} \sim N(0, \sigma_v^2)$, independent of u_{it}

Technical inefficiency effect u_{it}:

$$u_{it} = u_i \exp(-\eta(t - T)), \tag{3}$$

u_i ... non-negative random variables assumed to be i.i.d. as truncation at zero of the $u_i \sim N(\mu, \sigma_u^2)$ distribution
η parameter allowing for time-varying inefficiency

Model with Determinants (Battese & Coelli, 1995):

$$u_{it} = \delta \mathbf{z}_{it} + \omega_{it}, \tag{4}$$

$\mathbf{z}_{it}$ ... vector of determinants of inefficiency of DMU_i at time t
δ is a vector of parameters to be estimated
ω_{it} ... random variable defined by truncation of the normal distribution with zero mean and variance σ^2

Theoretical model

- Estimation using Maximum Likelihood - parametrization (Battese & Corra, 1997):

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \tag{5}$$

$$\gamma = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)}.$$

- u_{it} obtained as conditional expectation upon the observed value (Jondrow et al., 1982):

$$\epsilon_{it} = v_{it} + u_{it} = y_{it} - \beta x_{it} \tag{6}$$

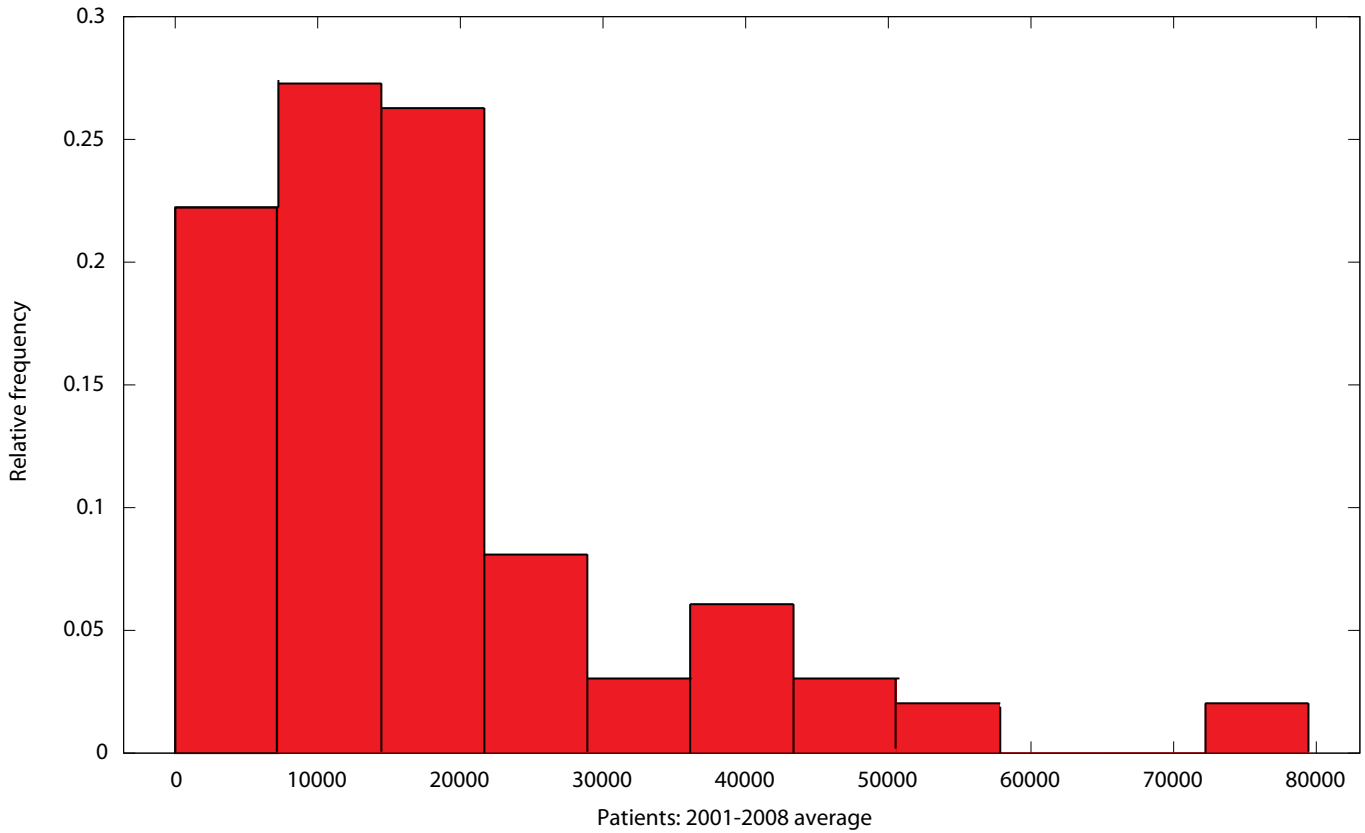
$$E[u_{it}|\epsilon_{it}] = \frac{\sigma\lambda}{1+\lambda^2}\left[\frac{\phi(a_{it})}{1-\Phi(a_{it})} - a_{it}\right], \tag{7}$$

$\lambda = \frac{\sigma_u}{\sigma_v}$ $a_{it} = \pm\frac{\epsilon_{it}\lambda}{\sigma}$ $\phi(a_{it})$ is the standard normal density evaluated at a_{it} $\Phi(a_{it})$ is the standard normal cumulative distribution function evaluated at a_{it}

Data - overview

- 99 General Hospitals: 2001–2008
- unbalanced panel: 661 observations
- data sources:
  - Institute of Health Information and Statistics of the Czech Republic
  - Czech Statistical Office
  - Registry of Companies of the Czech Republic
- adjustment for inflation using 2001 as a base
- estimation software:
  - Frontier Version 4.1 (Coelli, 1996)
  - R 2.8.1 (R Development Core Team, 2006)
  - Gretl (Cottrell & Lucchetti, 2007)

Size Distribution of Hospitals



Data - Cost Function Variables

- Dependent Variable: total operating costs
- Independent Variables:
  - inpatient days – (operative + non–operative + intensive) + nursing days
  - per day doctor/bed ratio
  - per day nurse/bed ratio
- Input prices: average monthly wages for districts

Data - Determinants of Inefficiency

- teaching status
- size
  - small: below 10,000 patients (size1)
  - medium: 10,000–20,000 (size2)
  - big: above 20,000 (size3)
- not–for–profit ownership status
- population size in municipality
- share of the elderly in municipality
- number of hospitals in the region

Descriptive Statistics

Inputs & outputs	No. obs.	Mean	Median	Minimum	Maximum	Std. Dev.
costs	661	5.072E+08	2.971E+08	4.037E+07	3.506E+09	6.090E+08
non_op_days	661	68771	46666	6759	296140	59798
op_days	661	52111	39272	5124	227318	41510
intense_days	661	14318	7918	723	109552	17355
sum_3_days	661	135200	93795	16062	607026	115660
nursing_days	370	17490	14937	3892	52470	10472
doctor_10_beds	660	1.4728	1.3998	0.4370	3.7606	0.3878
nurse_10_beds	660	5.3495	5.1632	2.6329	13.7757	1.0805
salary	661	15897	15463	11894	24416	2572
Determinants						
teaching	661	0.1241	0	0	1	0.3299
size1	661	0.3147	0	0	1	0.4647
size3	661	0.3570	0	0	1	0.4791
not_profit	661	0.7216	1	0	1	0.4485
population	661	65255	27544	3107	373272	89686
over_65	661	14.173	14.250	8.800	18.300	1.650
competition	661	15.9123	14	5	28	6.7074

Baseline Model

	Coefficient	S.E.	t-ratio	
β_0	6.66479	0.81254	8.202	***
sum_3_days	0.53309	0.04292	12.42	***
nursing_days	−0.00989	0.00788	−1.255	
doctor_bed	0.07115	0.03835	1.855	*
nurse_bed	0.20919	0.07111	2.942	***
salary	0.62413	0.07079	8.817	***
σ^2	0.22084	0.01669	13.23	***
γ	0.93729	0.00852	110.06	***
μ	0.90993	0.07609	11.96	***
Log likelihood function			229.61	
LR one-sided error			612.79	***

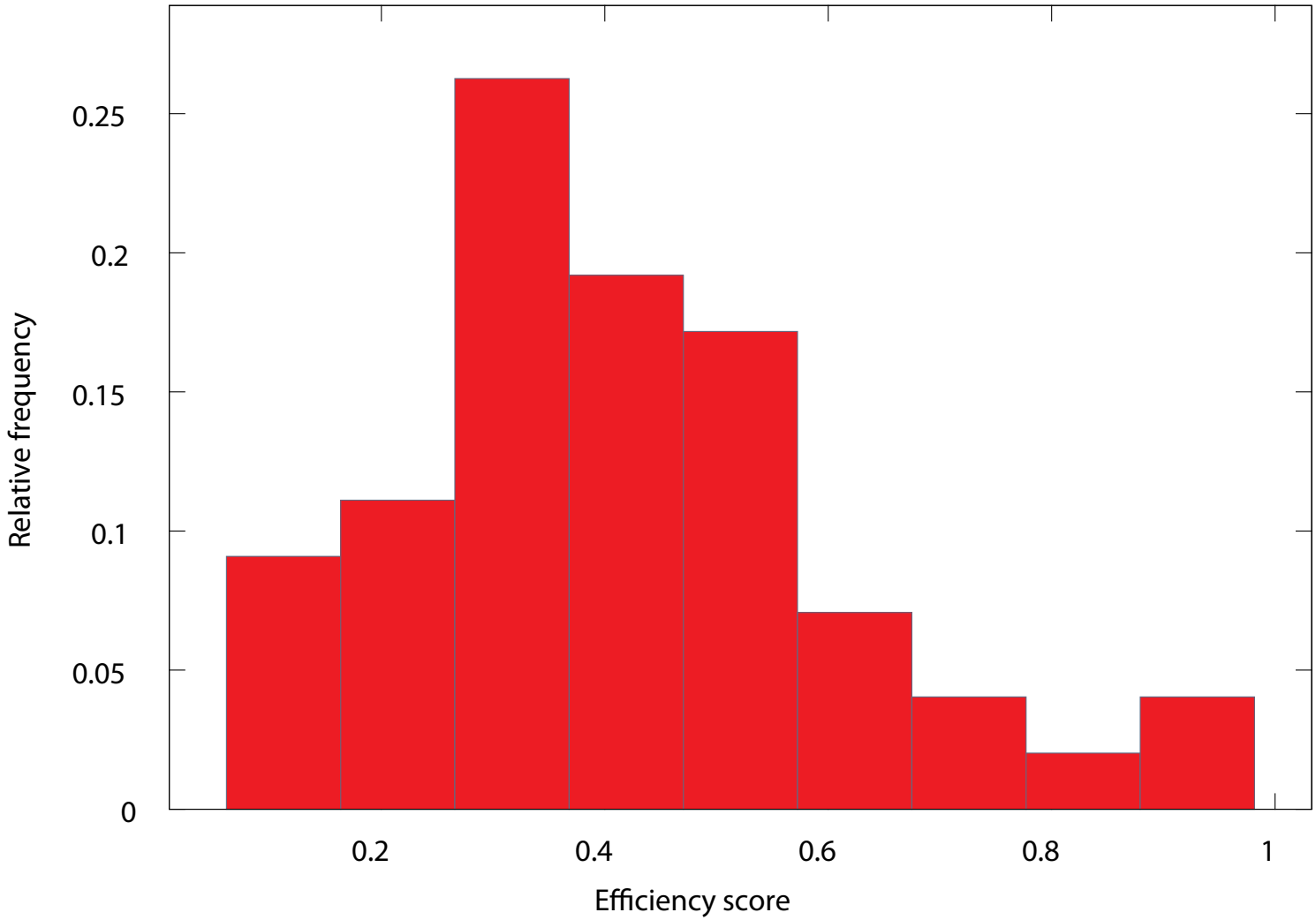
Note: ***significant at 1% level, * significant at 10% level.

Efficiency Scores – Baseline Model

- Summary Statistics

	Whole sample	Size 1: $\leq$ 10,000	Size 2: 10,000–20,000	Size 3: $>$ 20,000
mean	0.4105	0.5895	0.3993	0.2428
min	0.1124	0.3730	0.1124	0.1132
max	0.9305	0.9138	0.9305	0.3794
st.dev.	0.1922	0.1452	0.1533	0.0768
no. obs.	99	33	33	33

Distribution of Efficiency Scores – Baseline Model



Model with Determinants

	Coefficient	S.E.	t-ratio	
β_0	6.33286	1.02738	6.164	***
sum_3_days	0.84386	0.03293	25.63	***
nursing_days	0.01676	0.00235	7.132	***
doctor_bed	0.37563	0.05380	6.982	***
nurse_bed	0.68356	0.06603	10.35	***
salary	0.45600	0.09724	4.689	***
δ_0	0.03765	0.08395	0.448	
teaching	0.42822	0.05008	8.551	***
size1	−0.23717	0.06650	−3.567	***
size3	0.08460	0.04144	2.042	**
not-profit	0.14022	0.04417	3.174	***
population	−4.89E-07	0.00000	−3.062	***
over_65	0.00566	0.00424	1.336	†
competition	−0.00413	0.00268	−1.540	†
σ^2	0.06313	0.00393	16.06	***
γ	0.01387	0.00627	2.214	**
Log likelihood function			−24.19	
LR one-sided error			105.16	***

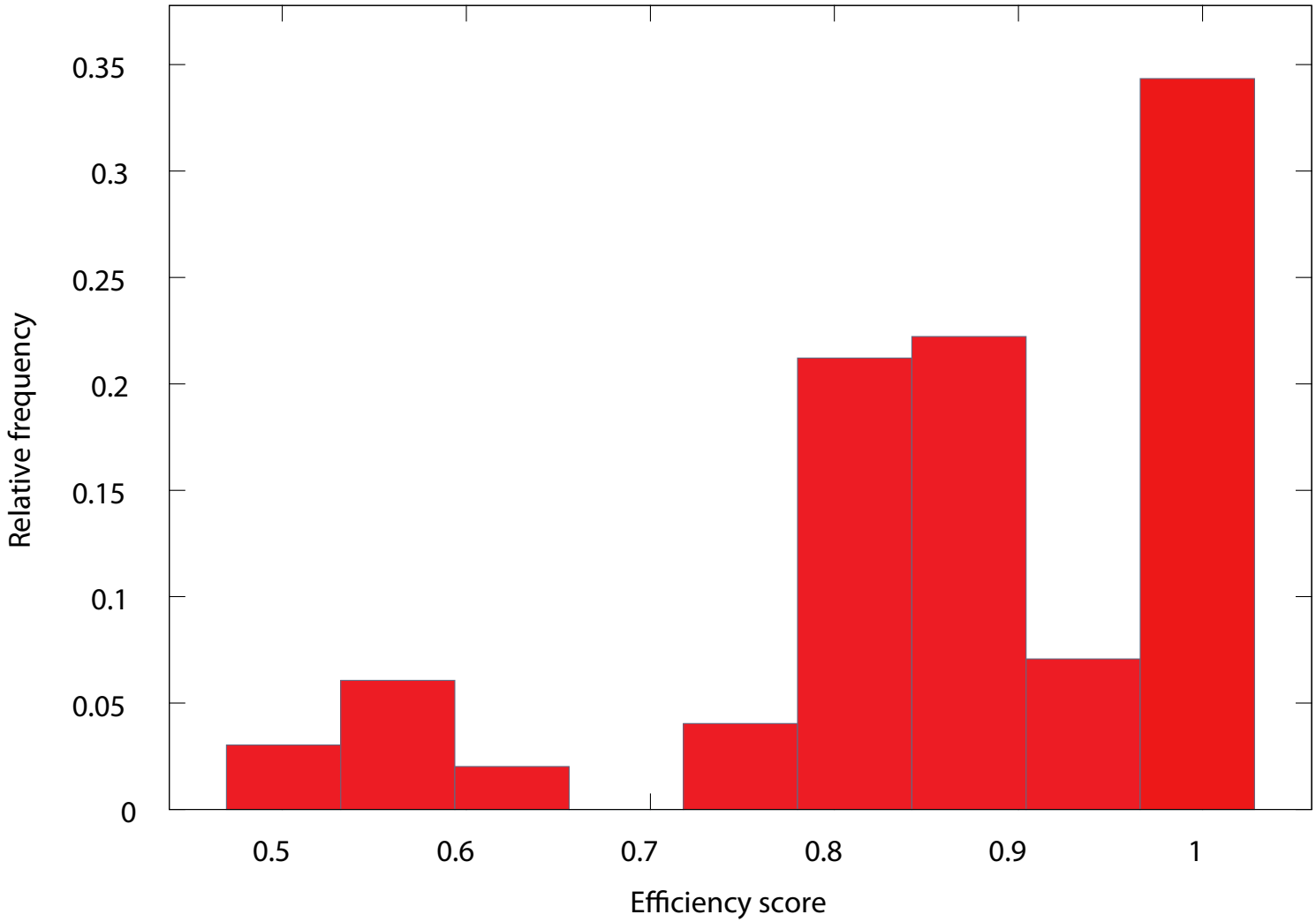
Note: *** significance at 1% level, ** significance at 5% level, † one-tail significance at 10% level.

Efficiency Scores – Model with Determinants

- Summary Statistics

	Whole sample	Size 1: $\leq$ 10,000	Size 2: 10,000–20,000	Size 3: $>$ 20,000
mean	0.8634	0.9926	0.8753	0.7223
min	0.5007	0.9820	0.8086	0.5007
max	0.9972	0.9972	0.9818	0.8982
st.dev.	0.1328	0.0038	0.0379	0.1213
no. obs.	99	33	33	33

Distribution of Efficiency Scores – Model with Determinants



Major Improvements & Deteriorations of Ranks

Improvement			Deterioration		
size	ID	change	size	ID	change
2	Na Homolce, Praha	52	2	Valašské Meziříčí	−51
2	VN Praha	43	2	Svitavy	−35
1	VN Brno	40	2	Slaný	−34
1	Karvinská hornická	38	2	Trutnov	−33
1	Hodonín	28	2	Milosrdných bratří, Brno	−33
2	Kolín	27	3	Nové Město na Moravě	−33
3	Městská nemocnice Ostrava	26	3	Teplice	−25
3	Ústí n. Labem	24	3	Kyjov	−23
2	Benešov	24	1	Sušice	−23

Note: Plus denotes shifts towards higher ranks and visa versa. Size 1=small, 2=medium, 3=big hospitals.

Discussion

With determinants, efficiency increased on average by assymetric shifts:

- Spearman's Rank Correlation Coefficient for the whole sample only 0.8091
- on the disaggregated level Spearmanin's Rank Correlation Coefficient insignificant or significant with a low coefficient (big hospitals)
- average shift in rank by 13.5 for the whole sample
- Czech hospitals not on average overly inefficient when determinants included
- teaching hospitals, in particular, still inefficient even with determinants
- cosiderable disparity in the group of big hospitals

- Number of Hospitals in Intervals

	Whole sample	Small	Medium	Big	Teaching
<0.6	10	0	0	10	10
0.6–0.7	1	0	0	1	1
0.7–0.8	10	0	0	10	0
0.8–0.9	37	0	25	12	0
0.9–1	41	33	8	0	0
Total	99	33	33	33	11

Robustness Check - Estimation Results

Small and Medium Hospitals	coefficient		Big and Teaching Hospitals	coefficient	
β_0	8.17925	***	β_0	6.12483	***
sum_3_days	0.70939	***	sum_3_days	0.87489	***
nursing_days	0.01826	***	nursing_days	0.00527	*
doctor_bed	0.47505	***	doctor_bed	0.22218	***
nurse_bed	0.57275	***	nurse_bed	0.39396	***
salary	0.42148	***	salary	0.41466	***
δ_0	-0.47957	***	δ_0	0.18595	
size1	-0.46221	***	teaching	0.93296	***
not_profit	0.15892	***	not_profit	-0.40244	***
population	-0.146E-05	***	population	0.959E-06	***
over_65	0.04114	***	over_65	0.00665	
competition	0.00810	***	competition	-0.02975	***
σ^2	0.07492	***	σ^2	0.03630	***
γ	0.12765	***	γ	0.34391	***
log likelihood function	-36.22		log likelihood function	84.11	
LR test one–sided error	51.72	***	LR one-sided error	123.45	***

Robustness Check - Efficiency Scores

- Summary Statistics

Small & Medium (up to 20,000)			Big & Teaching (over 20,000)		
	Robustness Check	Whole sample		Robustness Check	Whole Sample
mean	0.8606	0.9340	mean	0.8663	0.7223
min	0.5920	0.8086	min	0.5223	0.5007
max	0.9797	0.9972	max	0.9860	0.8982
st.dev.	0.1138	0.0646	st.dev.	0.1575	0.1213
no.obs	66	66	no.obs	33	33

Conclusions

- Output variables increase costs as expected
- Inefficiency increases with:
  - teaching status
  - being very big
  - not–for–profit status
  - share of the elderly
- Efficiency increases with:
  - being very small
  - population in municipality
  - competitive pressures
- With determinants efficiency increased
- Asymmetric shifts
- Czech hospitals not overly inefficient
- Group of teaching and big hospitals deserves further attention

Conclusions

THANK YOU FOR YOUR ATTENTION ☺