Profit Efficiency and Ownership of German Hospitals

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The German Health Care System in 2003

The System

- System of cost reimbursement until 2004. Then: Introduction of capitation fees (DRG system)
- 50% increase in per capita costs since 1993
- €235 billion spent on health care in 2003 (11.1% of German GDP)
- 30% spent on hospitals
- Market characterised by regulation of prices, quality, service provision, and location

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Research Questions

- Technical and cost inefficiency had been detected in the system (Herr, 2008).
- Private hospitals are less cost efficient than public hospitals (in Germany, USA)
- However, private hospitals make higher profits and face lower risks of insolvency.
- Puzzle?

Results

- With new data (2002–2006), no difference across ownerships when looking at technical and cost efficiency
- increase in efficiency scores, mean cost efficiency at around 94%
- private hospitals are significantly more *profit* efficient

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How to measure efficiency?

Definition of efficiency:

- *Technical efficiency*: minimise input use given a certain output level
- *Cost efficiency*: technical efficiency + input allocative efficiency given input prices and a certain output level
- *Profit efficiency*: cost efficiency + output allocative efficiency as well as some scale efficiency given input prices, output prices, amount of quasi-fixed inputs, and a certain output level.
- Profit efficiency: Producers face output prices p, input prices w and seek to maximise profits ($\pi = p^T y - w^T x$) by choosing the best input-output combination.

Existing methods

- DEA: deterministic, algorithm constructs frontier around data points, no assumptions but problems with definition of outliers
- SFA: stochastic, assumptions on production function and distribution of noise and efficiency

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Literature overview: Hospital cost efficiency studies

Author	Method	Least efficient type
Germany		
Helmig & Lapsley (2001)	DEA	Private
Werblow & Robra (2006)	DEA	Public
Staat (2006)	DEA	no significant diff.
Herr (2008)	Truncated SFA	Private
Schreyögg & Tiemann (2009)	DEA	Private
Werblow et al. (2009)	DEA	Public
Herwatz & Strumann (2010)	DEA	Private & Non-profit
USA		
Hollingsworth (2003)	DEA	mainly Private (for-profit)
Zuckerman & Hadley (1994)	Half-normal	Private (for-profit)
Folland & Hofler (2001)	Half-normal	Private (for-profit)
Rosko (1999)	2 step	Private (for-profit)
Rosko (2001, 2004)	Truncated	Private (for-profit)
Brown (2003)	Truncated	Private (for-profit)
Switzerland		
Farsi & Filippini (2006, 2008)	2 step, trunc.	no significant diff.

The base group varies between only non-profit, only public and non-profit and public hospitals.

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Literature overview: Profit efficiency studies

Author	Country	market	method
agriculture			
Ali & Flinn (1989)	Pakistan	Basmati rice	SFA, 1-equ.
Ali et al. (1994)	Pakistan	farms	SFA, 1 equ.
Khumbhakar (2001)	Norway	salmon farms	NLITSUR
banking			
Akhavein et al. (1997)	USA	banks	NLITSUR, with DFA
Berger & Mester (1997)	USA	banks	DFA, 1-equ.
Khumbhakar (2006)	USA	banks	cost eff., SFA
health			
Bradford & Craycraft (1996)	USA	hospitals	2SLS, with SFA
Knox et al. (1999)	Texas, USA	nursing homes	SUR, with OLS

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Estimation Strategy

- Estimate technical (output: number of weighted cases) and cost efficiency (output: total adjusted costs) and profit efficiency (dep. var.: EBIT, EAT) and compare
- Assumptions
  - Cobb Douglas production function
  - random noise: normally distributed
  - inefficiency: truncated-normally distributed and to depend on exogenous variables such as ownership type, region, and patients' characteristics
  - only one output, output price is fixed $\rightarrow$ one step model feasible
- Pool data over time, cluster by hospital
- Predict expected efficiency conditional on the estimated composite error
- Bootstrap standard deviations to test for differences in group means by ownership type

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SFA

Cobb-Douglas production function assumed

Log-linear **profit model**

$$\ln \frac{\pi_i}{w_{ki}} = \beta_0 + \sum_{n \neq k} \beta_n \ln \frac{w_{ni}}{w_{ki}} + \beta_y \ln p_i + \beta_b \ln b_i + \underbrace{v_i - u_i}_{\epsilon_i},$$

where y_i is a single output, $w_i = [w_{1i}, \ldots, w_{Ki}]$ is the vector of input prices of variable inputs x_i, b_i is a quasi-fixed input, v_i is random noise and $\beta = [\beta_1, \ldots, \beta_N]'$ is the vector of parameters to estimate. $u_i \geq 0$ is the output decreasing inefficiency.

Distributional assumptions

$$\begin{array}{lll} v_i & \sim & N[0, \sigma_v^2], \\ u_i & \sim & N^+[z_i'\delta, \sigma_u^2], \\ u_i \text{ and } & & v_i \text{ are independent of each other and of the regressors.} \end{array}$$

firm-specific (time variant) variables $z_i = [z_{1i}, \ldots, z_{Ki}]'$ account for heterogeneity of the hospitals

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The Hospital Statistics of the Statistical Offices of the Länder

- full set of German hospitals, 1,800 general hospitals
- full set of patient data (17 mio treatments per year) aggregated on diagnosis level (830,000-930,000 observations per year)
- patients statistic contains: age, sex, death, main diagnosis (ICD 9, 3 digits), length of stay (los)
- information about los of each diagnosis treated in each hospital enables construction of case-mix weights
- years 2002 to 2006

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The Hospital-Database of the RWI

- balance sheets of 541 hospitals over 1-4 years with more than 100 beds
- information on EBIT, EAT (earnings after tax), turnover
- urban vs. rural dummy

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Profit Efficiency: Specification

Standard Profit Efficiency

- dependent variable

  EBIT/EAT

- independent variables

  costs per doctor as price for variable labour input
  costs per nurse (used for normalisation)
  costs per other staff
  medical requirements per case
  number of beds (quasi-fixed input)
  base rate (Basisfallwert) as exogeneous output price

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Exogenous influences on inefficiency: z_i

- private and non-profit vs. public ownership
- eastern vs. western Germany
- share of female patients
- ratio of patients older than 75 years
- ratio of surgeries
- Hirshman-Herfindahl-index (HHI) per county
- urban vs. rural
- reform: after vs. before 2004 (shift in profit frontier)
- year dummy variables: change in inefficiency

Not feasible in hospital statistics

- ratio of privately insured patients
- quality other than death ratio

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Results: SFA, Profit Efficiency

effects on profit frontier	ln EBIT (adjusted)[a]		ln EAT (adjusted)[a]	
ln costs per doc[b]	0.014	(0.026)	-0.050	(0.021)**
ln costs per other staff[b]	0.012	(0.014)	-0.008	(0.019)
ln medical requirements/ case[b]	0.013	(0.006)**	0.006	(0.007)
ln base rate[b]	0.036	(0.030)	0.161	(0.012)***
ln number of beds	0.011	(0.006)*	0.013	(0.006)**
reform	0.896	(0.015)***	-0.009	(0.016)
constant	0.470	(0.106)***	0.864	(0.068)***
exogenous variables (effects on *in*efficiency)				
private	-0.227	(0.091)**	-0.158	(0.055)***
non-profit	-0.144	(0.091)	-0.097	(0.057)*
year=2003	-4.375	(1.729)**	-3.543	(0.901)***
year=2004	0.729	(0.049)***	-0.436	(0.054)***
year=2005	-1.249	(0.324)***	-3.727	(1.120)***
year=2006	-5.583	(1.759)***	-0.537	(0.080)***
constant	1.191	(0.117)***	1.354	(0.116)***
N	1,579		1,579	
coefficients on east, urban, HHI, elderly, surgery, female: insignificant				

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The

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Robustness Checks

- generalized model: it is not assumed that hospitals are input allocative efficient
- two-step SFA (1. half-normal model, 2. OLS on efficiency scores)
- Fixed-effects estimator, assuming that fixed effects captures inefficiency
- mortality rate as quality indicator

Tabelle: Pairwise correlation coefficients of profit and cost efficiency rankings across different models.

	SFA cost eff.	SFA profit efficiency		OLS FE
model	truncated	truncated	half-normal	
dependent variable	adj. costs	EBIT	EBIT	EBIT
SFA truncated: EBIT	0.17*	1		
SFA half normal: EBIT	0.23*	0.93*	1	
OLS Fixed Effects: EBIT	0.06	0.59*	0.47*	1
public	0.12*	-0.23*	-0.18*	-0.16*
non-profit		0.05	0.09*	
private	-0.10*	0.24*	0.12*	0.23*

The highest efficiency score has the highest rank. Printed correlation coefficients are significant at a 5% level, correlation coefficients additionally marked with $*$ are significant at a 1% level.

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Conclusion: Cost, Technical, and Profit Efficiency

- First study to analyse profit efficiency of German hospitals (and to compare with cost and technical efficiency)
- Private (for-profit) ownership exhibits **higher profit efficiency** than public ownership but not significantly diff. cost or technical efficiency
- Reasons may lie in specialisation, higher flexibility, need to gain more capital for investments
- From a welfare perspective, cost-reduction is probably preferred to profit maximisation in publicly financed markets. However, private hospitals may provide higher quality. Thus, no clear decision for or against privatisation yet to make.

To do

- Identify behavioural incentives of different hospital ownership types
- Account for hospital quality, identify good measure for Germany

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Finally

Thank you for your attention and your comments!

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Case-Mix-Weights

Los for each diagnosis $m = 1, \ldots, M$ over all German hospitals $i = 1, \ldots, I$:

$$los_m = \sum_i days_{mi} / \sum_i cases_{mi}.$$

Mean length of stay over all diagnoses and hospitals:

$$los_G = \frac{1}{M} \sum_m los_m$$

which is 8.9 days in 2003.
The number of weighted cases in hospital i:

$$w\_cases_i = \sum_m \frac{los_m}{los_G} cases_{mi} = \sum_m \pi_m cases_{mi}$$

with $\frac{1}{M} \sum_m^M \pi_m = 1$.

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Results: Cost and Technical Efficiency

	cost efficiency log adjusted costs		technical efficiency log weighted cases	
	cost frontier		technical frontier	
	cost and production frontier variables			
reform	-0.020	(0.008)**	0.005	(0.010)
constant	-1.153	(0.234)***	3.664	(0.172)***
exogenous variables (effects on *in*efficiency)				
private	0.770	(0.687)	0.791	(0.689)
non-profit	0.150	(0.417)	0.455	(0.473)
eastern Germany	0.985	(0.544)*	0.750	(0.426)*
urban	0.203	(0.267)	0.143	(0.147)
HHI	-0.709	(0.678)	-0.571	(0.660)
ratio of elderly patients	4.992	(1.951)**	2.588	(0.905)***
surgery-ratio	-0.697	(0.580)	-0.210	(0.251)
ratio of female patients	-5.000	(2.373)**	-1.988	(1.081)*
year=2003	0.079	(0.168)	0.101	(0.127)
year=2004	0.121	(0.194)	0.025	(0.134)
year=2005	-0.320	(0.254)	-0.122	(0.137)
year=2006	-0.488	(0.327)	-0.301	(0.157)*
constant	-0.098	(1.162)	-0.561	(1.336)
Sample Size N	1,579		1,579	

SFA estimates. a: Costs per nurse used for normalisation. Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Clustered at hospital

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Robustness Checks I: Generalised SFA

effects on profit frontier	ln EBIT (adjusted)[a]		ln EAT (adjusted)[a]	
ln costs per doc[b]	-0.012	(0.025)	0.018	(0.018)
ln costs per nurse[b]	0.066	(0.033)**	0.037	(0.025)
ln costs per other staff[b]	-0.015	(0.012)	-0.014	(0.018)
ln medical requirements/ case[b]	-0.011	(0.005)**	-0.013	(0.006)**
ln number of beds	0.015	(0.007)**	0.014	(0.006)**
reform	1.504	(0.026)***	0.098	(0.027)***
constant	5.01	(0.150)***	5.141	(0.145)***
exogenous variables (effects on *in*efficiency)				
private	-0.597	(0.358)*	-0.563	(0.337)*
non-profit	-0.451	(0.339)	-0.405	(0.289)
year=2003	-13.046	(7.784)*	-11.744	(6.060)*
year=2004	0.965	(0.247)***	-1.122	(0.397)***
year=2005	-3.628	(1.601)**	-13.878	(7.666)*
year=2006	-17.863	(7.219)**	-1.106	(0.416)***
constant	2.033	(0.231)***	2.293	(0.272)***
Sample Size N	1,579		1,579	
coefficients on east, urban, HHI, elderly, surgery, female: insignificant				

Robust standard errors in parentheses. Clustered at hospital level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The signs of the exogenous variables' coefficients are to be

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Robustness Checks II: OLS fixed effects

- predict fixed effects
- assume that unobserved heterogeneity mirrors inefficiency
- regress calculated relative efficiency scores on factors using OLS

	Efficiency scores based on FE-estimtes			
effects on efficiency	based on EBIT		based on EAT	
private	0.059	(0.015)***	0.026	(0.008)***
non-profit	0.026	(0.013)**	0.016	(0.007)**
eastern Germany	-0.035	(0.022)	-0.023	(0.012)**
year=2003	0.033	(0.039)	-0.003	(0.021)
year=2004	0.001	(0.033)	-0.003	(0.018)
year=2005	0.049	(0.033)	-0.001	(0.018)
year=2006	0.031	(0.030)	-0.005	(0.016)
constant	-0.026	(0.055)	0.025	(0.030)
Sample Size N	540		540	
urban, HHI, elderly, surgery, female insig.				

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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