Productive Efficiency and Ownership When Market Restructuring Affects Production Technologies

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Outline

1. Introduction and Literature
2. Data
3. Model
4. Empirical Results
5. Conclusions

Outline

I. Introduction and Literature

German Electricity Distribution Sector

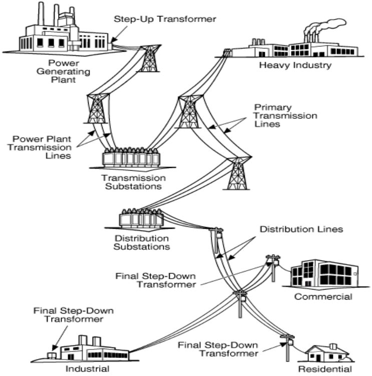


Figure: http://zone.ni.com/reference/en-XX/help/373375B-01/lveptconcepts/ep_grids/

- DSOs operate networks which distribute electricity on a local level
  - Tasks of DSOs:
    - Operate the grid
    - Provide a connection to each consumer
    - Strength the network in a reasonable manner
  - 883 firms in 2012 in Germany
  - Natural monopoly

Surrounding conditions of DSOs

Sector has undergone reasonable changes during the last 20 years:

- Liberalization
- Unbundling
- "Incentive" Regulation introduced in 2009
- German Energiewende

Ownership Structure of the Distribution Sector

- Privatization paradigma in the 1990's
- Recently, de-privatization (re-municipalization)
  - Numerous concession contracts have been expired
  - Increase of public influence
  - Favourable conditions for remunicipalization

→ Since 2005, about 200 networks have been remunicipalized

Remunicipalization

There is an ongoing political debate about remunicipalization.

- Examples for referendums:
  - Hamburg: successful remunicipalization in 2014
  - Berlin: rejection of the referendum in 2013

Critical view of German Monopolies Commission and German Cartel Office

- Fear a lack of efficiency of publicly owned firms
- Higher costs and prices for consumers

Literature: Ownership and Firms' Performance

- Agency theory: principal-agent dilemma
- Property rights: public ownership attenuates property rights, (Alchian and Demsetz, 1973; Demsetz, 1967)
- Public choice: politicians impose their objectives on public firms, (Shleifer and Vishny, 1994; Villalonga, 2000; Boardman and Vining, 1989)
- Regulated Firms: Superiority of private versus public firms depends on contract (Laffont and Tirole, 1991 and 1993)

Empirical Evidence

Conclusions from international empirical studies

- No differences between publicly and privately owned firms
  - Atkinson and Halvorsen (1986)
- Private firms outperform publicly owned ones
  - Bagdadiogul et al. (1996)
  - Kumbhakar and Hjalmarsson (1998)
- Public firms reach a higher efficiency level
  - Kwoka (2005)

$\Rightarrow$ **Empirical literature not conclusive.**

Research Question

Is there an efficiency gab between public and privately owned firms in electricity distribution?

Outline

II. Data

Data Set

AFiD Data Set

- German Federal Statistical Office (FDZ), official micro data
- All German utilities ($>$ 10 employees)
- Panel covers the years 2005 to 2012

Ene't Data Set

- Information of the distribution networks
- Grid-specific network charges
- Characteristics of municipalities
- Panel covers the years 2003 to 2014

Definitions of Variables

Variable	Name	Type	Defintion
y_C	number of consumers	output variable	in Thous.
y_E	electricity distributed	output variable	in Mwh
x_N	network length	input variable	in km
x_L	amount of worked hours	input variable	in hours
z_D	consumer density	operation environment	per km2
z_O	share of overhead lines	operation environment	km per km
own	ownership structure		Dummy

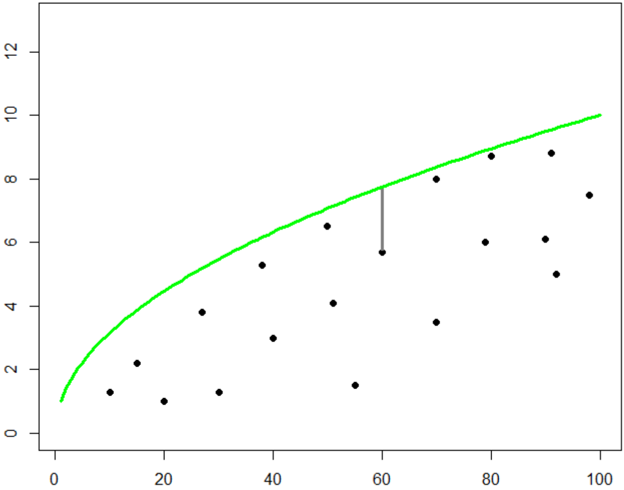
Sample Size

	2006	2007	2008	2009	2010	2011	2012
Number of Obs.	179	225	280	306	311	293	303
Number BNetzA	876	877	855	862	866	869	883

Outline

III. Model and Estimation

Introduction to Technical Efficiency



Model

Multi-Output Production Technology via Input Distance Function

- IDF are extensively used for modeling inefficiency in electricity distribution (Kumbhakar & Sun, 2012)

  → Inputs are endogenous and outputs are exogenous

  → Firms minimize costs, input ratios are exogenous, (Das & Kumbhakar, 2012)

- IDF representation of the transformation function (Kumbhakar, 2013) $X_1^{-1} = f(\tilde{X}, Y)$

$$-\ln x_{L,it} = \theta + \beta_N \ln(\tilde{x}_{j,it}) + \sum_{k \in \{C,E\}} \gamma_k \ln(q_{k,it}) + \sum_{l \in \{D,O\}} \delta_l \ln(z_{l,it}) + v_{it}$$

Flexible Stochastic Input Distance Frontier Model (Sun et al., 2015)

Technology parameters are unknown smooth functions of firm and/or time effects (non neutrally shift)

$$
\begin{aligned}
-\ln x_{L,it} &= \theta(i,t) \\
&+ \sum_{j \in \{N\}} \beta_j(t) \ln(\tilde{x}_{j,it}) \\
&+ \sum_{k \in \{C,E\}} \gamma_k(t) \ln(q_{k,it}) \\
&+ \sum_{l \in \{D,O\}} \delta_l(t) \ln(z_{l,it}) + v_{it}
\end{aligned}
$$

Interpretation of Inefficiency

Frontier concept: Difference between the minimal input and the actual observed inputs of the firms

$$\theta(i,t) = \alpha(t) + m_{it}$$
$$with \;\; \alpha(t) = \max_i \; \theta(i,t)$$

$$\begin{aligned} -\ln x_{L,it} &= \alpha(t) + \beta_N(t)\ln(\tilde{x}_{j,it}) + \sum_{k\in\{C,E\}} \gamma_k(t)\ln(q_{k,it}) \\ &+ \sum_{l\in\{D,O\}} \delta_l(t)\ln(z_{l,it}) + \underbrace{v_{it} - \underbrace{u_{it} + \mu_i - \eta i}_{m_{it}}}_{\varepsilon_{it}} \end{aligned}$$

Outline

IV. Results

Estimation Results

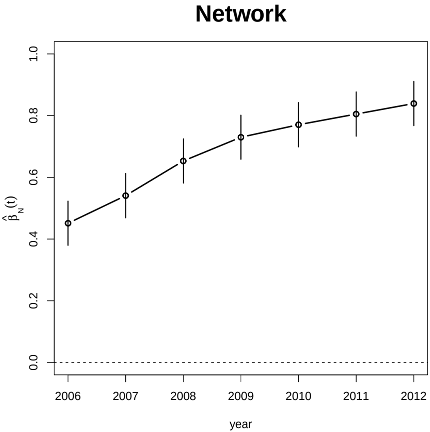
Table: Estimated coefficients of the input distance function

Year	$\hat{\beta}_N(t)$	$\hat{\gamma}_C(t)$	$\hat{\gamma}_E(t)$	$\hat{\delta}_D(t)$	$\hat{\delta}_O(t)$
2006	0.4512*	-0.0088	-0.0029	0.0159	0.0139
2007	0.5407*	-0.0057	-0.0065	0.0151	0.0391*
2008	0.6531*	-0.0035	-0.0108	0.0125	0.0675*
2009	0.7300*	-0.0137	-0.0149*	0.0196	0.0480*
2010	0.7705*	-0.0347*	-0.0166*	0.0367*	-0.0085
2011	0.8051*	-0.0653*	-0.0236*	0.0575*	-0.0419*
2012	0.8393*	-0.1051*	-0.0410*	0.0783*	-0.0526*

Note: * denotes the significance at the 10 percent level.

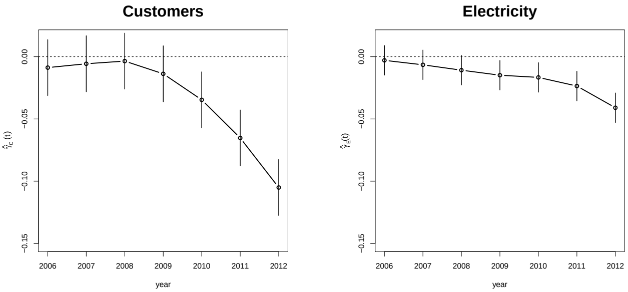
Development of Input Coefficient

Figure: Input coefficient, $\hat{\beta}_N(t)$, over time



Development of Output Coefficients

Figure: Output coefficients, $\hat{\gamma}_C(t)$ and $\hat{\gamma}_E(t)$, over time

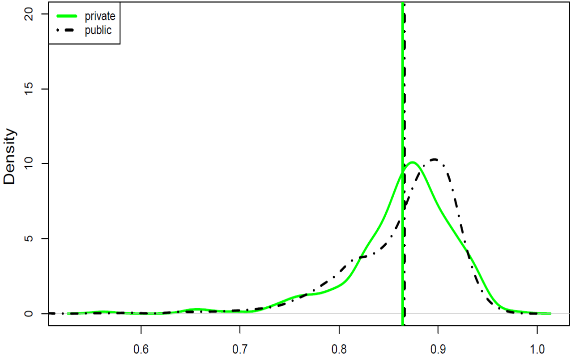


Efficiency Scores

Table: Transient efficiency scores $TE_{tran,it} = exp(-u_{it})$

Year	Type	25% Quart.	Median	Mean	75% Quart.
2006	public	0.7953	0.8248	0.8230	0.8631
	private	0.8758	0.8985	0.8744	0.9240
2007	public	0.7777	0.8021	0.8090	0.8370
	private	0.8265	0.8627	0.8594	0.9150
2008	public	0.8206	0.8445	0.8433	0.8728
	private	0.8294	0.8525	0.8535	0.8819
2009	public	0.8820	0.8927	0.8931	0.9068
	private	0.8539	0.8788	0.8740	0.9097
2010	public	0.8754	0.8895	0.8874	0.9039
	private	0.8613	0.8742	0.8706	0.8894
2011	public	0.8716	0.8965	0.8873	0.9130
	private	0.8515	0.8702	0.8666	0.8855
2012	public	0.8685	0.8956	0.8829	0.9144
	private	0.8244	0.8718	0.8527	0.8942

Distribution of Transient Efficiency Scores



→ Wilcoxon rank sum test with continuity correction

→ H0: Both groups have the same mean (p-value = 0.1919)

Outline

V. Conclusions

Conclusions

- The common technology frontier shows a development over time
- Publicly owned firms do not perform less efficient compared to private ones
- Concerns of the German Monopolies Commission are not supported

Thank you for your attention

Backup - Further Empirical Evidence

- Focus on **US electricity sector**
  (Atkinson and Halvorsen, 1986; De Alessi, 1974; Peltzman, 1971; Rose and Joskow, 1990; Neuberg, 1977; Peters, 1993; Pollitt, 1995; Kwoka, 2005)
- Studies of the **EU's power markets** are scarce
  (Kumbhakar and Hjalmarsson, 1998; Arocena and Waddams Price, 2002)

Backup - Summary Statistics

Table: Summary statistics of the variables

Variable	Name	Type	25% Quart.	Median	Mean	75% Quart.	Std. Dev.
y_C	customers	public	7,996	15,707	25,572	26,776	36,998
		private	2,889	14,361	45,906	44,176	72,686
y_E	electricity	public	96,729	192,643	432,171	372,441	1,158,509
		private	40,624	240,329	1,033,875	891,961	2,158,137
x_N	network	public	253	431	674	732	928
		private	183	519	1,676	1,426	2,788
x_L	labor	public	47,672	94,241	133,304	163,870	141,701
		private	8,098	22,329	91,693	108,181	163,029
z_D	density	public	486	1,062	1,165	1,670	814
		private	466	833	1,085	1,509	896
z_O	overhead	public	0.02	0.06	0.08	0.12	0.08
		private	0.04	0.12	0.20	0.32	0.21

Backup - Sample Size

	2006	2007	2008	2009	2010	2011	2012	Sum
Number of Obs.	179	225	280	306	311	293	303	1897
Public	155	187	237	264	263	245	260	1611
Private	24	38	43	42	48	48	43	286
Number BNetzA	876	877	855	862	866	869	883	

Backup - Estimation Strategy

Adapted (Sun et al., 2015) to an input distance function
Estimation of slope coefficients via Robinson transformation and nonparametric regression

- Robinson transformation:

$$\begin{aligned} ln(x_{L,it})^* &= ln(x_{L,it}) - E(x_{L,it}|i,t) \\ ln(B_{it})^* &= ln(B_{it}) - E(B_{it}|i,t) \end{aligned}$$

- Estimation of the slope coefficients:

$$\begin{aligned} -ln(x_{L,it})^* = &\quad \phi(t)' ln(B_{it})^* + v_{it} \\ \rightarrow &\quad \hat{\phi}(t) \; and \; \hat{v}_{i,t} \end{aligned}$$

Backup - Estimation Strategy

- Estimation of $\hat{\theta}(i,t)$ via nonparametric regression

$$
\begin{aligned}
-ln(x_{L,it})^* &= \hat{\phi}(t)'ln(B_{it})^* + v_{it} \\
res_{it} &= -ln(x_{L,it}) - \hat{\phi}(t)'ln(B_{it}) \\
\rightarrow \hat{\Theta}(i,t) &= E(res_{it}|i,t)
\end{aligned}
$$

- Decomposition of $\hat{\theta}(i,t)$

$$
\begin{aligned}
\hat{\alpha}(t) &= \max_i\{\hat{\theta}(i,t)\} \\
\rightarrow \hat{m}_{it} &= \hat{\theta}(i,t) - \hat{\alpha}(t)
\end{aligned}
$$

Backup - Estimation Strategy

- Recall the definition of the components of $\hat{\epsilon}_{it}$

$$\epsilon_{it} = v_{it} - \underbrace{u_{it}}_{\textbf{Trans.Ineff.}} + \underbrace{\mu_i}_{\textbf{Firm Effect}} - \underbrace{\eta_i}_{\textbf{Pers.Ineff.}}$$

- Rewrite $\hat{\epsilon}_{it}$

$$\epsilon_{it} = \underbrace{E(-u_{it}) + E(\mu_i) + E(-\eta_i) + E(v_{it})}_{\alpha_0} + \underbrace{\mu_i - [\eta_i + E(-\eta_i)]}_{\psi_i} + \underbrace{v_{it} - [u_{it} + E(-u_{it})]}_{\chi_{it}}$$

Backup - Estimation Strategy

- Decomposition of $\hat{\epsilon}_{it}$

$$\begin{aligned} \hat{\epsilon}_{it} &= \alpha_0 + \psi_i \cdot D_i + \chi_{it} \\ &\rightarrow \hat{\alpha}_0, \hat{\psi}_i, \hat{\chi}_{it} \end{aligned}$$

- Estimation of persistent efficiency

$$\begin{aligned} \hat{\psi}_i &= \tau_0 + \eta_i - \mu_i \\ &\rightarrow \hat{\mu}_i \end{aligned}$$

- Estimation of transient efficiency

$$\begin{aligned} \hat{\chi}_{it} &= \lambda_0 + v_{it} - u_{it} \\ &\rightarrow \hat{u}_{it} \end{aligned}$$

Backup - Robustness Checks

Table: Estimated coefficients of the input distance function using stochastic frontier model

Model	$\hat{\beta}_N(t)$	$\hat{\gamma}_C(t)$	$\hat{\gamma}_E(t)$	$\hat{\delta}_D(t)$	$\hat{\delta}_O(t)$
SFA without firm effect	0.8958***	-0.4381***	-0.3019***	0.1538***	-0.0157*
SFA with firm effect	0.8979***	-0.0120	-0.0269	0.0289	0.0259

Note:*** denotes a significance level smaller than 0.1 percent,
* denotes the significance at the 5 percent level.