Consolidating the Water Industry

An Analysis of the Potential Gains from Horizontal Integration in a Conditional Efficiency Framework

Michael Zschille

Michael Zschille
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Agenda

1 Introduction and Motivation

2 Methodology

3 Data and Model Specification

4 Results

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1 Motivation

- High fragmentation of German water supply: 6211 water utilities (Umweltbundesamt, 2010, p. 75)
- Consolidation e.g. in England & Wales and the Netherlands, fragmentation e.g. in Portugal and Japan
- Formerly consolidated water industry in East Germany (16 utilities); more than 550 utilities after 1990
- Evidence for scale economies in water supply across different countries (Saal et al., 2011)
- German Monopolies Commission claims for consolidation (Monopolkommission, 2010)

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- Evaluation of current market structure
- Determination of returns to scale characteristics in German water supply
- Analyze the efficiency impact of horizontal integration in water supply

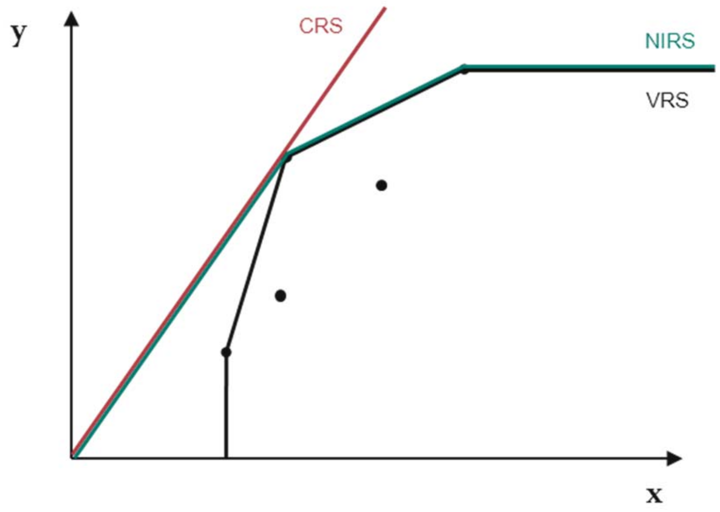
2 Methodology I – Data Envelopment Analysis

- **Data Envelopment Analysis (DEA)**
  - Nonparametric approach based on linear programming
  - Assumption of input-orientation
  - Different returns to scale (RTS) technologies possible: constant (CRS), variable (VRS), non-increasing (NIRS) and non-decreasing (NDRS)
  - Simple production model
    - Inputs: number of employees, network lengths
    - Outputs: water delivered to final customers, water delivered to other water utilities, number of connections

- **Conditional efficiency framework** (Daraio and Simar, 2005, 2007)
  - Necessity to account for operating environment in efficiency analysis (e.g. different densities of supply)
  - Aim to compare like with likes
  - Estimation of a Kernel function for the environmental variables
  - Only observations with similar operating environment are used to construct the frontier
  - Consideration of:
    - Output density
    - Share of water losses
    - Share of groundwater input

2 Methodology II –Returns to Scale

- **Scale efficiency**
  - Scale efficiency: $SE = TE_{CRS}/TE_{VRS}$
- **Qualitative analysis of returns to scale**
  - Färe and Grosskopf (1985)
  - Comparison of frontiers obtained under different returns to scale assumptions
  - Classification into firms operating under IRS, CRS or DRS



- **Quantitative analysis of scale elasticity in DEA** (Førsund and Hjalmarsson, 2004)
  - Scale elasticity: maximum proportional expansion in outputs relative to a proportional increase in inputs (Førsund, 1996)
  - IRS for scale elasticity greater than one
  - Based on dual formulation of DEA program (with VRS)
  - Shadow price on RTS restriction used to calculate scale elasticity
  - Not uniquely defined for corner points, but: estimation of bounds

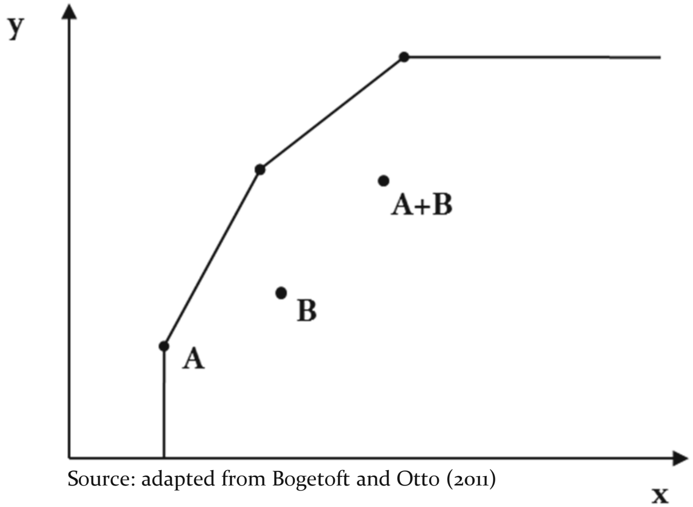
2 Methodology III – Horizontal Integration (Bogetoft and Wang, 2005)

- **Consideration of *J* firms to be merged out of the full set of observations *k={1,…, K}***

  - Merged firm DMU^J obtained by direct pooling of all inputs and outputs
  - Potential overall gains from horizontal integration calculated as:

$$E^J = \min\{E \in \mathbb{R}_+^{p+q} | (E\sum_{j\in J} x^j, \sum_{j\in J} y^j) \in \widehat{\Psi}_{DEA}^{*,z}\}$$

  - $\widehat{\Psi}_{DEA}^{*,z}$ denotes the pre-merger, conditional technology set



Source: adapted from Bogetoft and Otto (2011)

- **Decomposition into learning, harmony and scale effects:**

$$E^J = LE^J * HA^J * SI^J$$

- **Summary Statistics (364 observations, year 2006)**

	Abbr.	Min.	Median	Mean	Max.	Std. dev.
Inputs						
Employees [number]	*labor*	2.00	10.00	29.85	2326.00	139.97
Network length [km]	*net*	21.00	164.50	329.68	7858.00	600.80
Outputs						
Final water supplies [1000m³]	*wdel*	89.00	1154.50	3144.41	197 900.00	12 720.40
Bulk water supplies [1000m³]	*bws*	0.00	1.00	264.21	14 670.00	1130.43
Connections [number]	*con*	911.00	5437.00	10 837.61	262 000.00	22 751.33
Environmental variables						
Output density [ratio]	*mmw*	1.70	6.98	8.14	29.93	4.63
Water losses [ratio]	*losses*	0.00	0.11	0.12	0.40	0.06
Groundwater usage [ratio]	*ground*	0.00	1.00	0.83	1.00	0.31

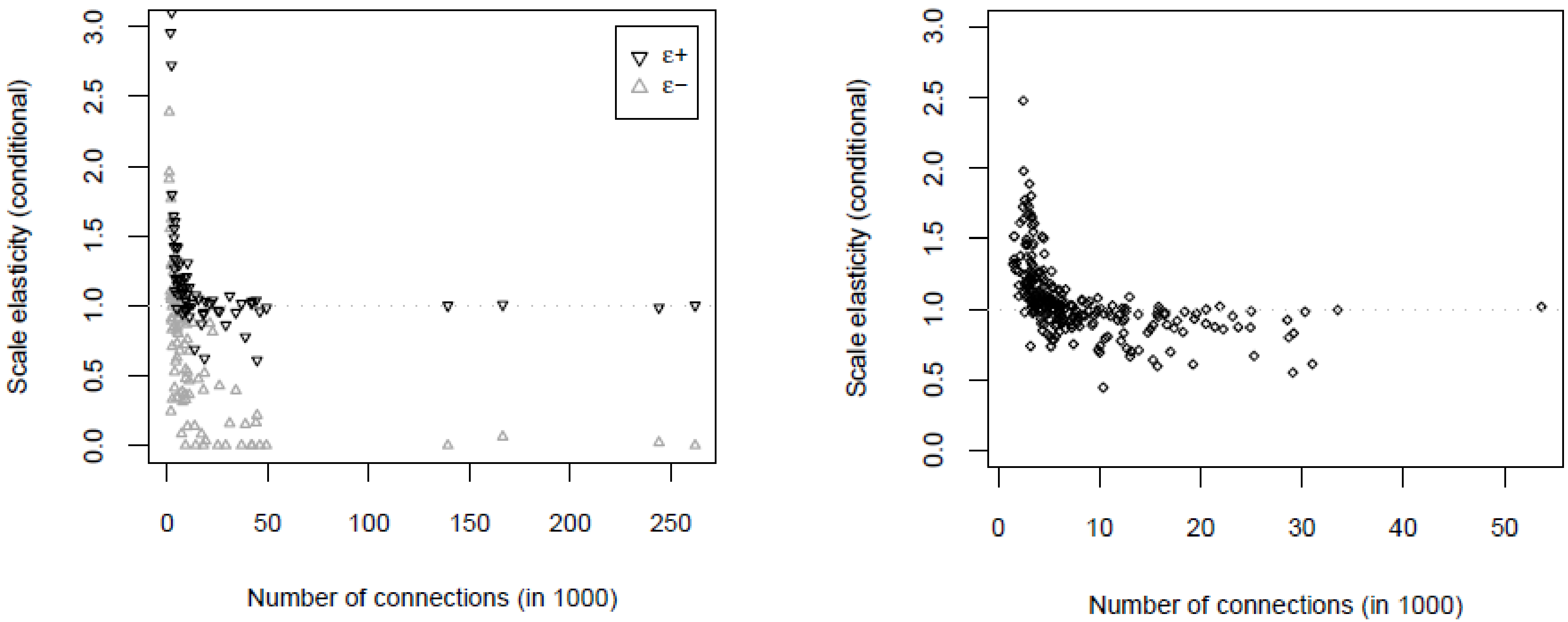
4 Results I – DEA Efficiency Scores

- **Summary of DEA efficiency scores**
  - Low overall efficiency levels
  - Significant increase in efficiency when controlling for operating environment
  - Mostly low scale inefficiencies, majority of observations operating under IRS

	Obs.	Min.	Median	Mean	Max.	Std. dev.
Standard DEA (VRS)						
full sample	364	0.2571	0.5988	0.6350	1.0000	0.1911
after outlier detection	356	0.2862	0.6872	0.7130	1.0000	0.1818
Conditional DEA (VRS)	356	0.3107	0.8505	0.8423	1.0000	0.1327
Scale Efficiency						
unconditional	356	0.5064	0.9669	0.9283	1.0000	0.0975
conditional	356	0.5348	0.9704	0.9344	1.0000	0.0846
Qualitative RTS		**# IRS**	**# CRS**	**# DRS**		
unconditional	356	203	20	133		
conditional	356	174	47	135		

Results II – Scale Elasticity Results

- **Scale elasticity for frontier units and inefficient units**
  - IRS for smallest utilities (scale elasticity > 1), CRS or DRS for larger utilities
  - Scale elasticity decreasing with increasing firm size
  - No clear conclusion on optimal firm size level



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Results III – Horizontal Integration

- **Horizontal Integration**
  - Consolidation on county-level ("Landkreise", NUTS3-regions)
  - In total: 84 cases of horizontal mergers of at least 2 utilities (maximum: 6, total: 227)
  - Not covering all water utilities in a county (missing data)
  - Assumption of non-decreasing returns to scale

- **Summary of potential gains and decomposition:**

	Sym.	Min.	Median	Mean	Max.	Std. dev.
Overall gains	E^J	0.3596	0.8248	0.8337	1.0703	0.0922
Corrected gains	E^{*J}	0.7978	0.9582	0.9592	1.1362	0.0740
Learning effect	LE^J	0.4238	0.8743	0.8714	1.0000	0.0924
Harmony effect	HA^J	0.8064	0.9699	0.9761	1.3356	0.0833
Scale effect	SI^J	0.7357	1.0000	0.9839	1.0000	0.0375

- **Most merger cases would be (more or less) beneficial!**

5 Conclusions

- High fragmentation of water supply in Germany
- High levels of technical inefficiency in some cases
- Accounting for operating environment leads to significant increase in efficiency estimates

- Scale efficiency usually high
- Majority of water utilities characterized by increasing returns to scale

- Horizontal integration in most cases results in efficiency gains
- But: high gains from improving individual efficiencies without any merger

- Only analysis of *potential* merger gains
- Neglects possible drawbacks of consolidation (market power, competitiveness, number of firms for future benchmark studies,…)
- Not all firms can be merged due to differing firm cultures, corporate identities, political circumstances, etc.

Thank you for your interest. Questions and comments are welcome!

DIW Berlin — Deutsches Institut
für Wirtschaftsforschung e.V.
Mohrenstraße 58, 10117 Berlin
www.diw.de

Michael Zschille
mzschille@diw.de

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