Strategic behavior by energy networks under yardstick regulation

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Outline

Background
- Incentive regulation
- Merger regulation

Models
- Frontier models
- Merger model
- Peer effect model

Analysis: Norway
- Regulation in Norway
- Predictability
- Cross-ownership
- Peer effects

Conclusion

INCENTIVE REGULATION

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Focus of regulation

Level of delegation

- Low: regulator intervenes in process
  - Heavy-handed regulation
  - Cost-review processes
  - Investment reviews
- High: firm free to decide upon all resources
  - Performance / output oriented regulation
  - Light-handed regulation

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Regulation and focus of model

Cost-review, weak incentives

- Command-control; process focus

Light-handed, weak incentives

- No horizontal competition: learning focus

Incentive regulation, strong incentives

- Performance assessment; outcome based

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Information access

Low

- Strong protection of operators
- Poor separation of operations
- Few operators
- Poor or tacit definition of task

High

- Competitive focus
- High separation of operations and costs
- Many operators (or collaboration)
- Clear explicit definition of task

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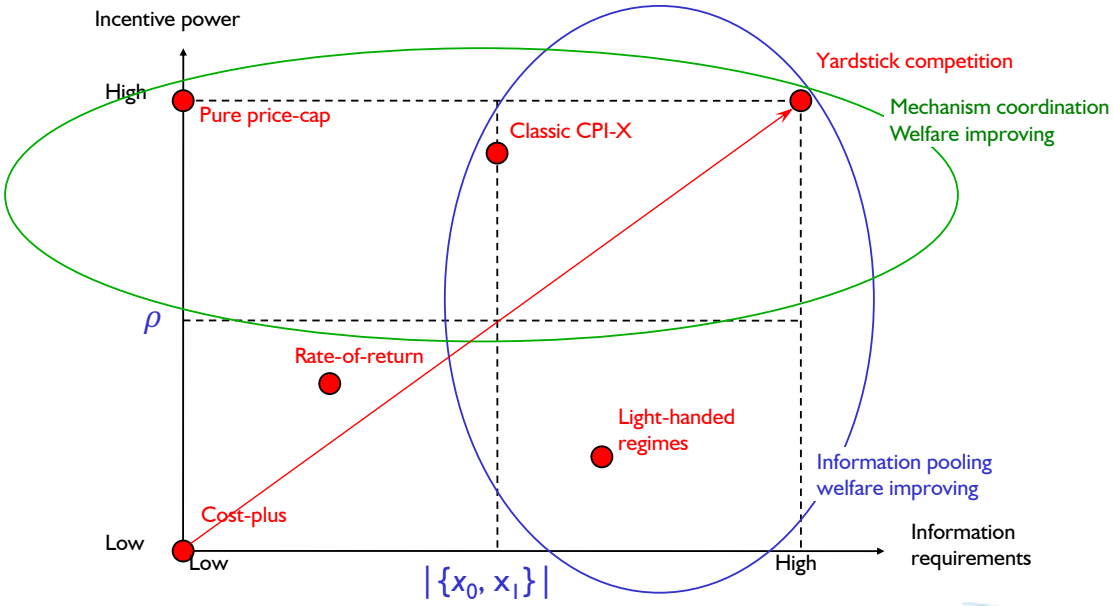
Incentive power and information access



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Frontier regulation with revenue cap

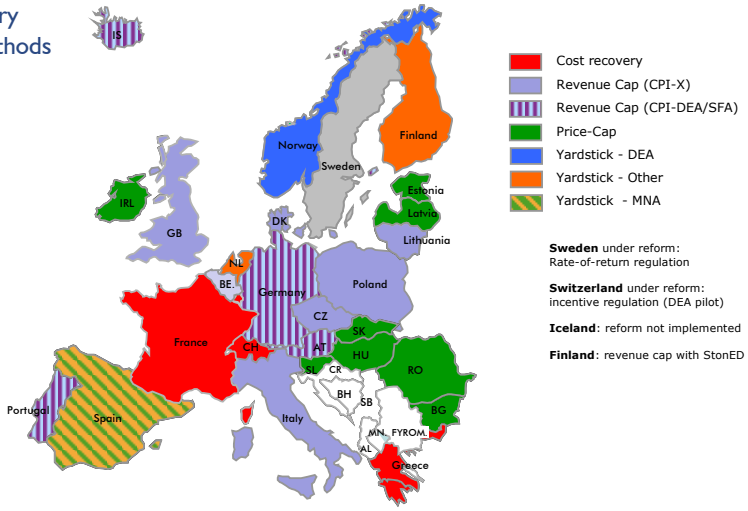
Revenue cap = R_0 CPI (1 – X – X_i)

Incentive regulation, corollaries

- The revenue is independent of the costs of the operator (Schleifer, 1985)
- Exogenous price changes are passed-through, Littlechild (1983
- The general productivity of the cap
- A utilitymaximizing firm cares about the incentive power

EU Regulatory landscape (Energy)

EU Regulatory landscape – Methods (Energy)



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Normative models are popular

Country	*Approach*	*Method*	*Analysis*	*Operation*
AUSTRALIA	Ex ante	CPI-DEA	x	x
AUSTRIA	Ex ante	DEA (EngM)	x	x
DENMARK	Ex ante	COLS → DEA	x	x
FINLAND	Ex ante	DEA->StonED	x	x
GERMANY	Ex ante	DEA/SFA Yard	x	x
NETHERLANDS	Ex ante	Cost Yard	x	x
NEW ZEELAND	Ex ante	CPI-DEA	x	x
NORWAY	Ex ante	CPI-DEA Yard	x	x
ICELAND	Ex ante	CPI-DEA	x	-
PORTUGAL	Ex ante	SFA	x	?
CHILE	Ex ante	EngM	x	x
SPAIN	Ex ante	EngM	x	x
ENGLAND	Ex ante	CPI-X	x	x
BELGIUM	Ex ante	CPI-DEA → CR	x	-
SWITZERLAND	Ex ante	(RoR) →?	x	-
SWEDEN	Ex ante	(EngM) →RoR	x	x

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MERGER REGULATION

Horizontal mergers?

Cost-driven

- Economies of scale
- Synergies (scope)
- Risk sharing
- Scarce managerial skills

Competition-driven

- Market power through
  - Scale
  - Scope
  - Collusion
- Information asymmetry

Theoretical reasons for merger

Implementation of collusion, not to improve efficiency, but to limit rent extraction by the regulator
- Auriol and Laffont, 1992; Tangerås, 2002; Dijkstra et al., 2017; Teusch, 2016.

Defense against hold-up by opportunistic governments (expropriation of sunk investments)
- Estache and Wren-Lewis, 2009.

Access to capital markets and lower financial costs in emerging markets

Size and scope to capture the regulator.
- Dal Bó, 2006; Agrell and Gautier, 2017.

"Malevolence hypothesis"

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Empirical investigations of network mergers

Productivity gains, (mixed) efficiency effects, ownership types – but no strategic concern
- Cox and Portes, 1998; Kwoka, 2005; Kwoka and Pollitt, 2010),
- Kumbhakar et al., 2015; Saastamoinen et al., 2017 [Scandinavian networks]

Gaming effects (but only as single-firm examples)
- Jamasb et al., 2003, 2004.

"Benevolence hypothesis"

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Literature on horizontal mergers in infrastructure

Yatchew (2000)
- Increasing economies of scale for DSO
- Minimal efficient scale from 20,000 customers

Filippini and Wild (2001)
- Strong economies of scale for small DSO
- MPSS around 100,000 customers

Bagdadioglu et al. (2007)
- Turkey (21 proposed mergers from 82 DSO, 1999-2003)
- Bogetoft-Wang model
- Strong synergy effects, overall 17% savings,
- No scale effect

Agrell et al. (2015)
- Norway (42 real mergers, 1995-2004)
- Bogetoft-Wang model
- Ex ante and ex post evaluation
- Small scale effects, small synergy effects
- Major effect short-term operating cost (labor vs services)

Scarce empirical material, contradictory results

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Regulatory policy towards horizontal mergers

Continental regulators
- Few and large DSO
- Poor "competition", high incentives
- Passive-aggressive towards mergers

Scandinavian regulators
- Many small concession areas
- High "competition", low incentives
- Supportive towards mergers, avoid gaming (reporting)

Ambivalent regulators
- Bi-modal distribution of DSO (midgets and giants)
- Two tier regulator for DSO $<$ 100,000 customers and $>$ 100,000
- Disincentives to merge, high uncertainty for DSOs

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Contributions of the paper

A new measure of strategic peer effect in network mergers
- Direct control
- Cross ownership
- Information rents (playing the regulation)

Empirical evidence of strategic mergers
- Norway, DSO
- Frontier yardstick, dynamic (Agrell-Bogetoft-Tind, 2005)
- Frontier estimate of anticipated merger gains (Bogetoft-Wang, 2005)

Policy implications
- Industrial structure
- Regulatory instrument

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Challenges

Direct effects
- Reduction of reference set
- Elimination of peer

Indirect effects
- Change of frontier for other firms
- Yardstick with cap: impact of reallocation of revenues

Cross-ownership effects
- No change to reference set
- Control split on several operators
- Impact on frontier behavior from controlled unit

FRONTIER MODELS

Basic activity model

$$T = \{ (x, y) \in \mathbb{R}_+^n \times \mathbb{R}_+^m \mid x \text{ can produce } y \}$$

Production plan $(x^k, y^k) \in \mathbb{R}_+^m \times \mathbb{R}_+^n$

Cost efficiency model DEA

$$
\begin{aligned}
D(x, y|\Omega, r) = \quad & \min_{\theta,\lambda} \quad \theta \\
& \text{s.t.} \quad \theta x \geq \sum_{i\in\Omega} \lambda_i x_i \\
& \qquad\quad y \leq \sum_{i\in\Omega} \lambda_i y_i \\
& \qquad\quad \lambda \in \Gamma(r)
\end{aligned}
$$

$$\Gamma(r = \text{crs}) = \mathbb{R}^n_0, \Gamma(r = \text{vrs}) = \{\lambda \in \mathbb{R}^n_0 | \textstyle\sum_i \lambda_i = 1\}.$$

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Requirements for regulatory cost norms

A cost norm for regulatory use must respect

- Feasibility (evidence based estimate)
- Neutrality (unbiased estimate)
- Robustness (to data errors)
- Repeatability (endogeneity of parameters)

Model objective

- The cost norm is based on structural comparability
- The resulting rulings should be robust to judicial recourse

Agrell and Brea (2017)

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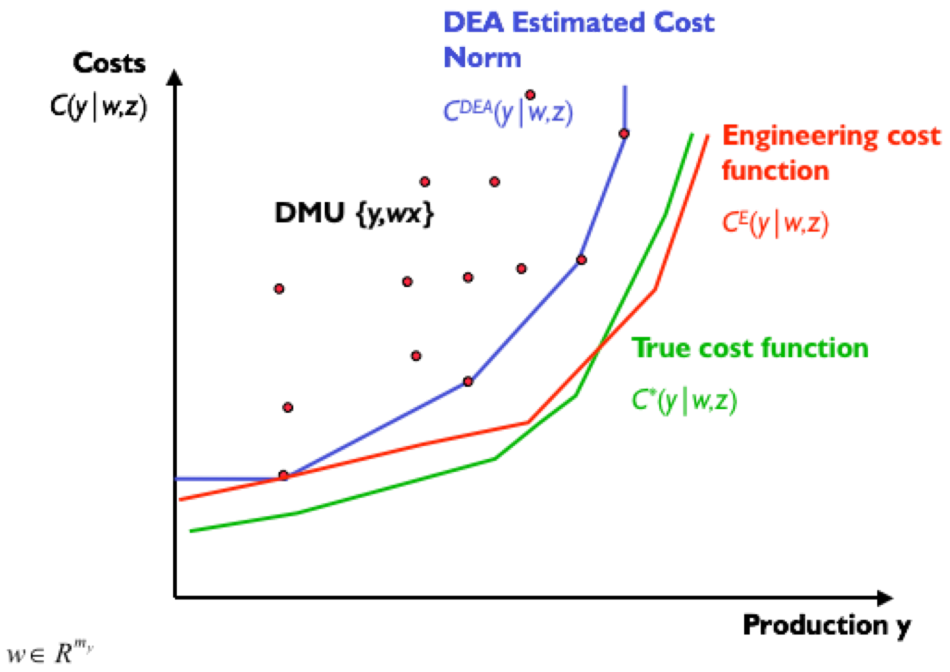
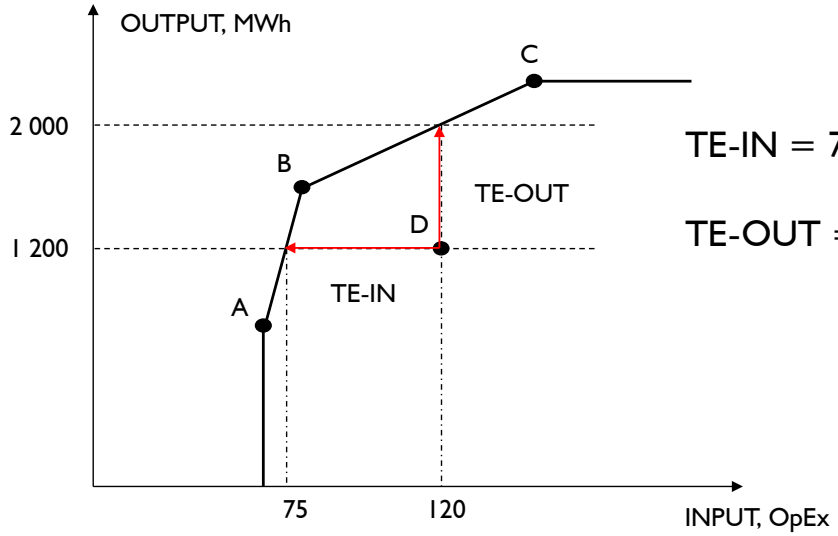
Feasibility



$w \in R^{m_y}$

(Relative) Technical Efficiency I



TE-IN = 75/120 = 62,5%

TE-OUT = 2000/1200 = 167 %

Efficiency Concepts

TECHNICAL EFFICIENCY (TE)

› Right methods, procedures etc given input and output mix

SCALE EFFICIENCY (SE)

› Right scale of operation (max output per input, min average cost)

COST EFFICIENCY (CE)

› Minimal cost given local prices

ALLOCATIVE EFFICIENCY (AE)

› Right input mix given prices

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Cost efficiency CE

$$CE(c_i, y_i|\Omega, r) = \frac{\hat{C}(y_i|w)}{c_i} = D(c_i, y_i|\Omega, r)$$

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Bogetoft and Wang (2005)

$$E^M = L^M \cdot H^M \cdot S^M$$

E	Overall efficiency of merger
L	Learning effect of merger
H	Scope effects of merger
S	Size effects of merger

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Overall gains E

$$E^M = \min\{E \in \mathbb{R}^+ \mid (E \sum_{k \in M} x^k, \sum_{k \in M} y^k) \in T\}$$

If $E^M < 1$, the merger produces savings, and if $E^M > 1$, the merger is costly.

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Adjusted overall gains E*

Firm, and use the projected plans $(E^k x^k, y^k)$, $k \in M$, as the basis for calculating the *adjusted overall gains* E^{*M} from the merger:

$$E^{*M} = \min \{\theta \in \mathbb{R}^+ \mid (\theta \sum_{k \in M} E^k x^k, \sum_{k \in M} y^k) \in T\}.$$

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Learning effect L

$$L^M = \frac{E^M}{E^{*M}},$$

0 ≤ L ≤ 1 takes into account the catch-up of inefficiency by initially inefficient DSOs in the merger

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Scale effect S

The *scale effects* S^M are captured by asking how much could have been saved by operating at full rather than average scale:

$$S^M = \min_{S \in \mathbb{R}^+} \{ (S \cdot H^M \sum_{k \in M} E^k x^k, \sum_{k \in M} y^k) \in T \}.$$

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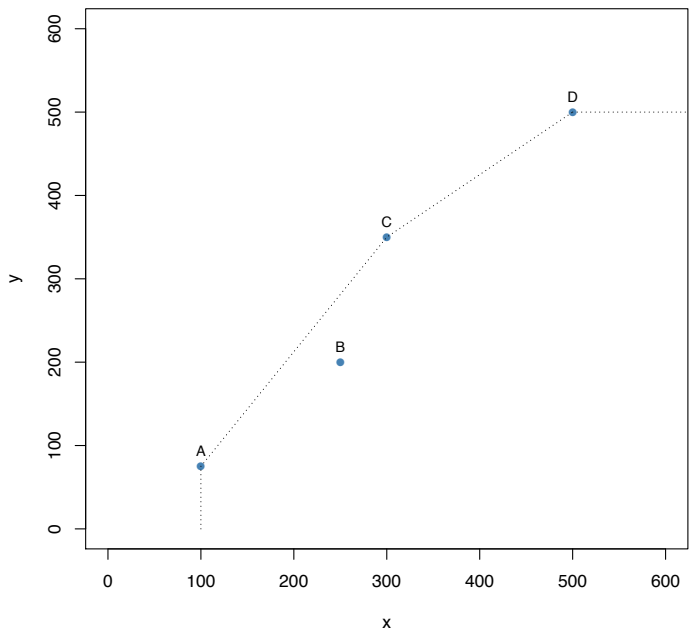
Scope gains H

The *scope gains* H^M are derived from the average input reduction in the production of the average output:

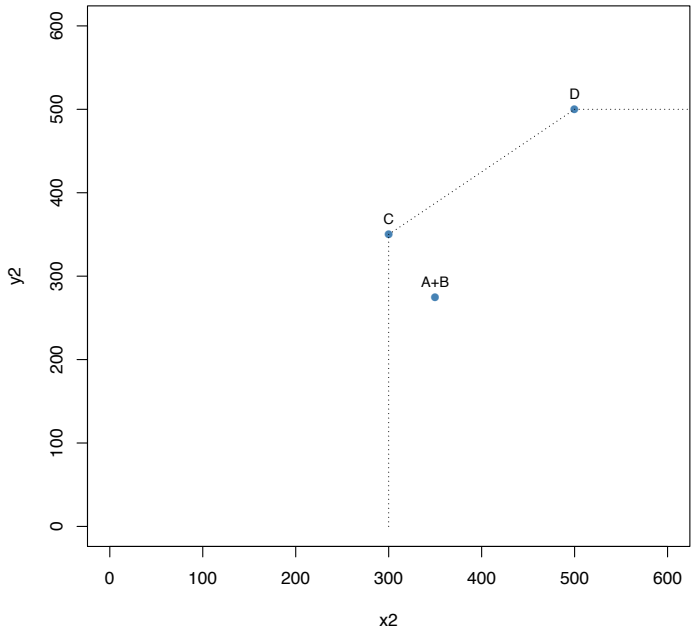
$$H^M = \min_{H \in \mathbb{R}^+} \{ (H \frac{\sum_{k \in M} E^k x^k}{|M|}, \frac{\sum_{k \in M} y^k}{|M|}) \in T \},$$

MEASURING STRATEGIC MERGERS

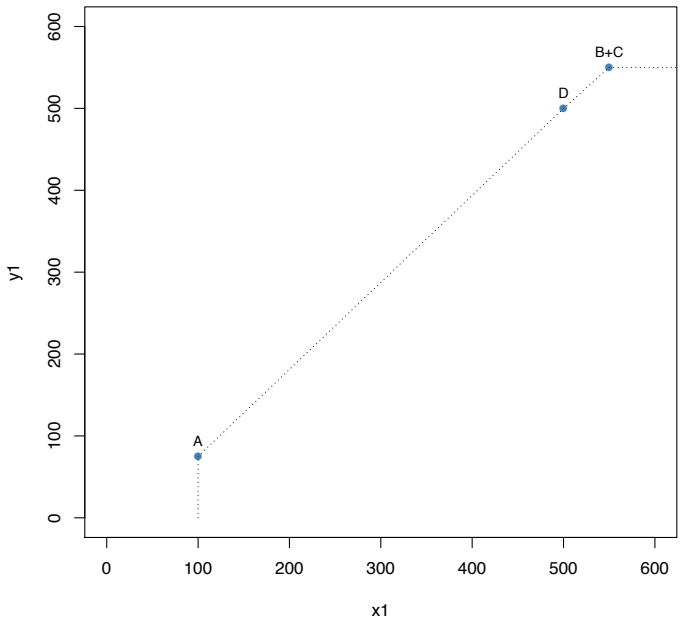
Unit B (76% efficient) merging…



Unit B (76% efficient) merging with A = 86% efficient



Unit B (76% efficient) merging with C = 100% efficient!



Importance of peer k

Definition 1. $\rho_{i,k} = \frac{\lambda_k^i}{\sum_k \lambda_k^i}$.

Relative impact of k on the target for i

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H1: Peer predictability

Predictability

- Important for investments
- Best practice regulation in energy transition

NRA changes DEA model to

- Fewer outputs
- Five-year averages
- Deterministic stable outputs

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Peer stability

Definition 2. $PS_i^t = \frac{1}{2}\sum_{j\in\Psi_i^{t-1}\cap\Psi_i^t}(\rho_{i,j}^{t-1} + \rho_{i,j}^t)$

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Peer effects

Definition 3. $\xi_{i,k}^t = \frac{D(x_i^t, y_i^t|\Omega^t, r)}{D(x_i^t, y_i^t|\Omega_{-k}^t, r)} \quad i, k \in \Omega^t$

Proposition 1. $0 < \xi_{i,k} \leq 1, \quad i, k \in \Omega^t$

Change in observed efficiency of *i* if firm *k* is removed

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Peer effect and profitability

Proposition 2. *Ceteris paribus, firm i's profit increases after peer k disappears from the frontier if and only if $\xi_{i,k} < \tilde{\xi}_{i,k}$, where $\tilde{\xi}_{i,k} \equiv \frac{\sum_{j \neq i} c_j^*}{\sum_{j \neq i} c_j^*/\xi_{j,k}}$ and $c_i^* \equiv c_i D(x_i, y_i|\Omega) \ \forall i, k \in \Omega$. Profitability increases in $\tilde{\xi}_{i,k} - \xi_{i,k}, \ \forall i, k \in \Omega$.*

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Cross-ownership

$$CP_{i,j \neq i} = \sum_g s_g^i \times \sum_g s_g^{j \neq i}$$

Measure of two firms' (i,j) cross-held shares for same owner g

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Peer effects of mergers

Definition 4. $\omega_i^M = \frac{D(x_i,y_i|\Omega^t,r)}{D(x_i,y_i|\Omega^M,r)},\ i \in \Omega^M.$

Change in efficiency score of *i* for merger M

Proposition 3. *Ceteris paribus, firm i's profit increases if and only if* $\omega_i^M < \tilde{\omega}_i^M,\ i \in \Omega^M$, *where* $\tilde{\omega}_i^M \equiv \frac{\sum_{j\neq i} c_j^*}{\sum_{j\neq i} c_j^*/\omega_j^M}\ \forall i \in \Omega^M$. *Profitability increases in* $\tilde{\omega}_i^M - \omega_i^M$.

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Efficiency effects of mergers

$$E_M = D(x_M, y_M|\Omega^t, r)$$

$$E_M = L_M \cdot \underbrace{H_M \cdot S_M}_{E_M^*}$$

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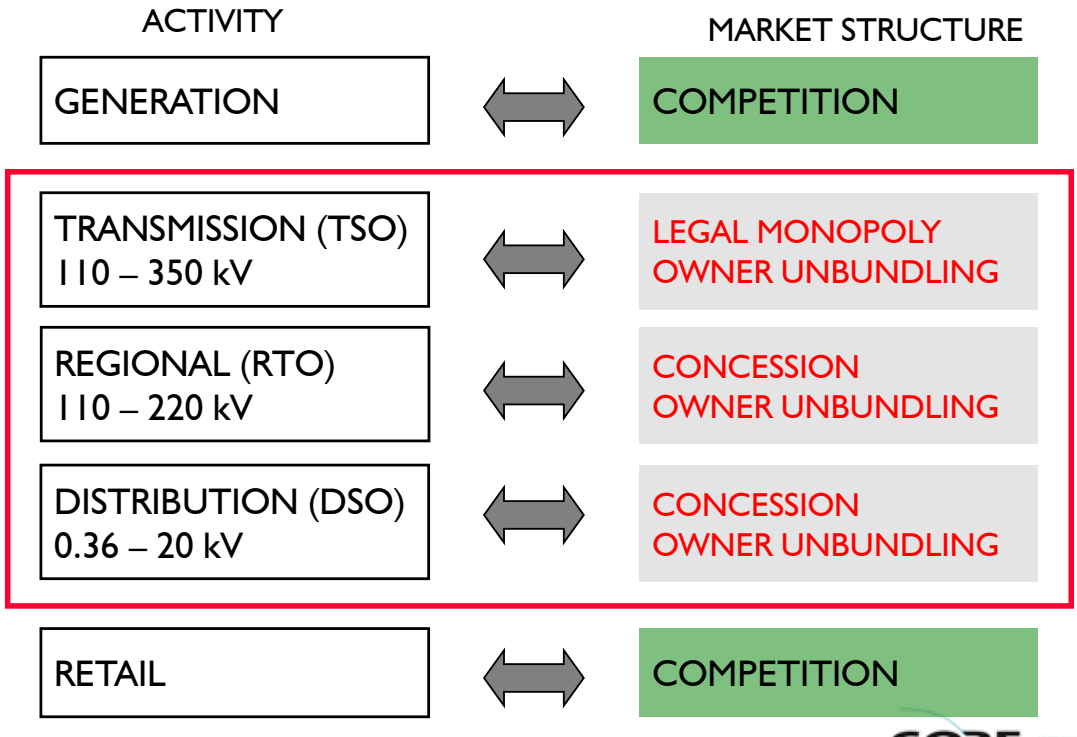
CASE OF NORWAY

Sector structure in Norway



Network regulation in Norway

1991 to 1996
- Rate of return regulation (RoR)

1997 to 2001
- Revenue cap regulation, with individual X based on DEA (ex post 1996)

2002 to 2007
- Revenue cap regulation, with individual X based on DEA (ex post 2001)
- DEA under VRS assumption

2007 to 2009
- DEA Yardstick model I (9 outputs), CRS

2010 to 2012
- DEA Yardstick model II (8 outputs), CRS

2013 -
- DEA Yardstick model III (3 outputs), CRS

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Norwegian revenue cap regulation

$$R^t(c_i^{t-2}, y_i^{t-2}|\Omega^{t-2}, \text{crs}) = \alpha\ \hat{C}(c_i^{t-2}, y_i^{t-2}|\Omega^{t-2}, \text{crs}) + (1-\alpha)\ c_i^{t-2},$$

Annual revenue cap — Cost norm DEA — Actual cost

Weight for cost norm (0.6)

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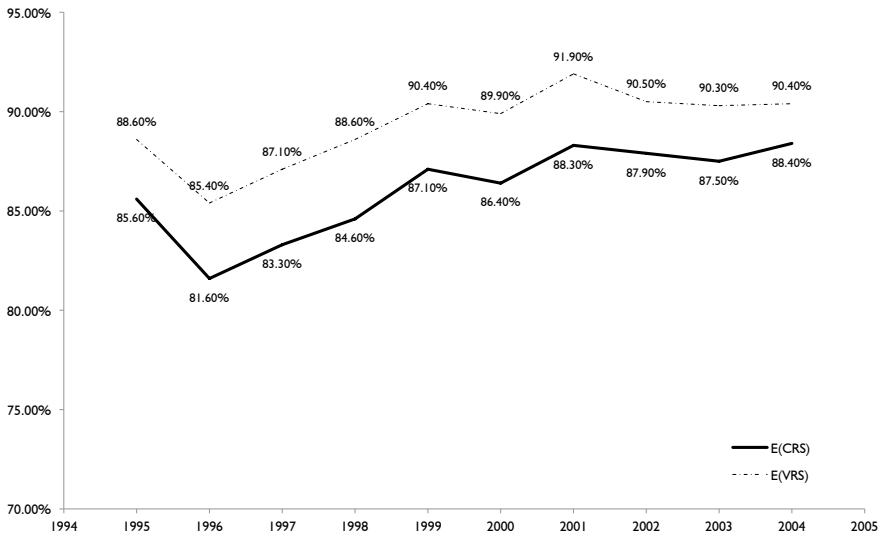
The effect of incentive regulation



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Data

Norwegian electricity DSO

Panel 2011-2015

Audited data from NRA, used in regulation

(NRA uses 5-year averages only for references, we use of all)

Mergers post 2013 :

- 13 mergers
- Only 5 contiguous adjacent area
- 28 involved operators

DEA models

Table 2: Outputs used in DEA model

Variable	Unit of measurement	2007-2009	2010-2012	2013+
Delivered energy	MWh	X	X	
Customers - cottages	#	X	X	
Customers - residential	#	X	X	
Customers - total	#			X
High-voltage (HV) lines	km	X	X	X
Substations	#	X	X	X
Transformers	Weighted measure	X		
Forest	Forest index × HV overhead lines	X	X	
Snow	Snow index × HV overhead lines	X	X	
Coast	Coast index × HV overhead lines	X	X	

Source: NVE (2012).

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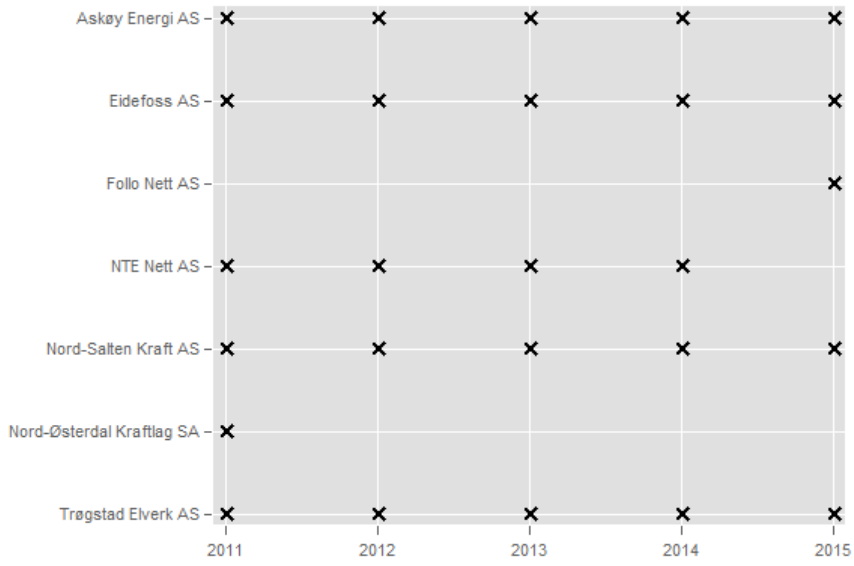
Frontier stability



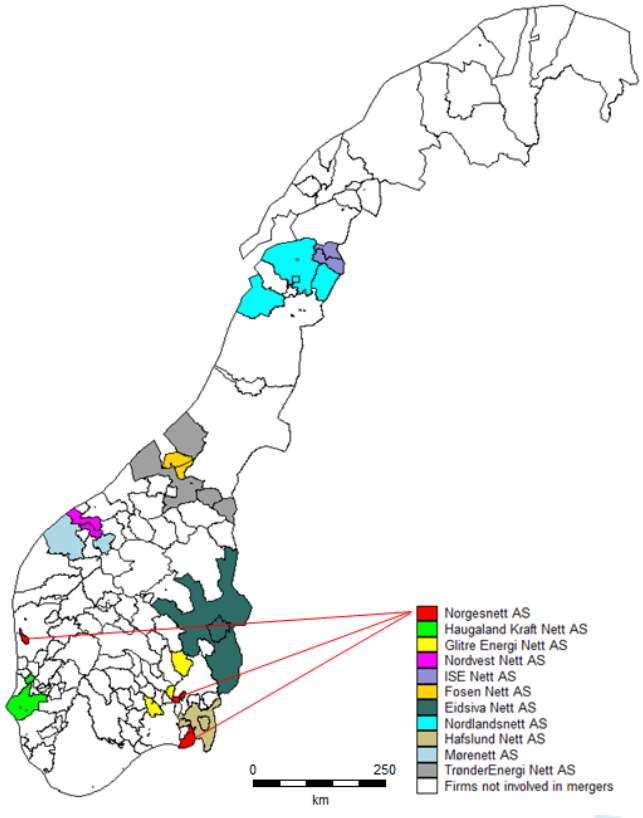
Mergers 2011-2015

Table 5: Mergers and takeovers ($2011 \leq t \leq 2015$)

Merged firm ($t+1$)	Constituent firms (t)	Year (t)
TrønderEnergi Nett AS	Malvik Everk AS, **TrønderEnergi Nett AS**, Tydal KF	2012
Mørenett AS	Tafjord Kraftnett AS, Tussa Nett AS	2013
Hafslund Nett AS	Fortum Distribution AS, **Hafslund Nett AS**	2013
Nordlandsnett AS	Dragefossen Kraftanlegg AS, **Nordlandsnett AS**	2013
Eidsiva Nett AS	**Eidsiva Nett AS**, Elverum Nett AS	2014
Fosen Nett AS	Fosen Kraft AS, Rissa Kraftlag SA	2014
ISE Nett AS	Fauske Lysverk As, Sørfold Kraftlag AS	2014
Nordvest Nett AS	Ørskog Energi AS, Vestnes Energi AS	2014
Glitre Energi Nett AS	EB Nett AS, Hadeland Energinett AS, Lier Nett AS	2015
Haugaland Kraft Nett AS	**Haugaland Kraft Nett AS**, SKL Nett As	2015
Nordlandsnett AS	**Nordlandsnett AS**, Rødøy-Lurøy Kraftverk AS	2015
Norgesnett AS	Askøy Energi AS, Follo Nett AS, Fredrikstad Nett AS	2015
TrønderEnergi Nett AS	Selbu Energiverk AS, **TrønderEnergi Nett AS**	2015

Note: In case of a takeover, the acquiring firm is marked in bold.
Sources: NVE, Company register and DSO websites.

Figure 6: Map of mergers and takeovers



Note: Geospatial data is from NVE's website.

Efficiency effects L,H,S

Table 8: Efficiency effects of mergers

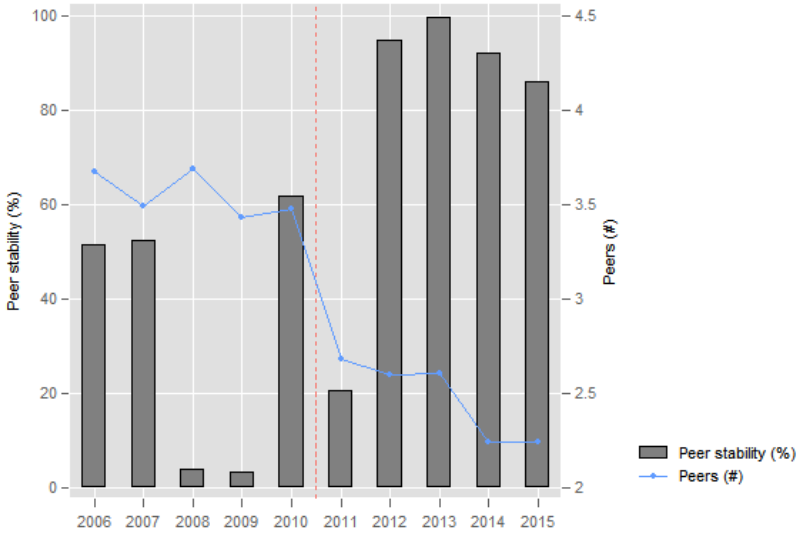
	Year	L_M	H_M	S_M
TrønderEnergi Nett AS	2012	0.78	1.00	1.03
Mørenett AS	2013	0.66	0.99	1.02
Hafslund Nett AS	2013	0.94	0.98	*
Nordlandsnett AS	2013	0.78	1.00	1.03
Eidsiva Nett AS	2014	0.84	1.00	1.25
Fosen Nett AS	2014	0.80	1.00	0.98
ISE Nett AS	2014	0.60	1.00	0.95
Nordvest Nett AS	2014	0.86	1.00	1.00
Glitre Energi Nett AS	2015	0.86	0.96	1.08
Haugaland Kraft AS	2015	0.71	1.00	1.01
Nordlandsnett AS	2015	0.72	0.99	1.04
Norgesnett AS	2015	0.96	0.99	1.05
TrønderEnergi Nett AS	2015	0.84	1.00	1.01

Characteristics of merging firms

Table 1: Summary statistics (2011-2015 averages)

	Mean	Median	Min	Max	N
Totex (in 2015-kNOK)	120524.9	48729.1	9872.6	1961914.9	112
Customers (#)	26405.0	7164	1043	689215	112
Substations (#)	1134.6	383.5	61	17940	112
HV lines (km)	899.2	350.5	58	11781	112
$CE(x, y)$	0.72	0.71	0.44	1	112

PS in Norway 2011-15



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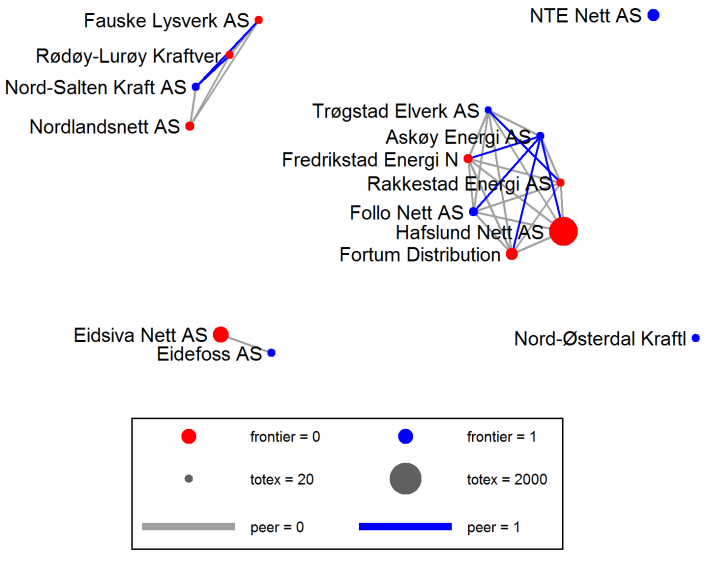
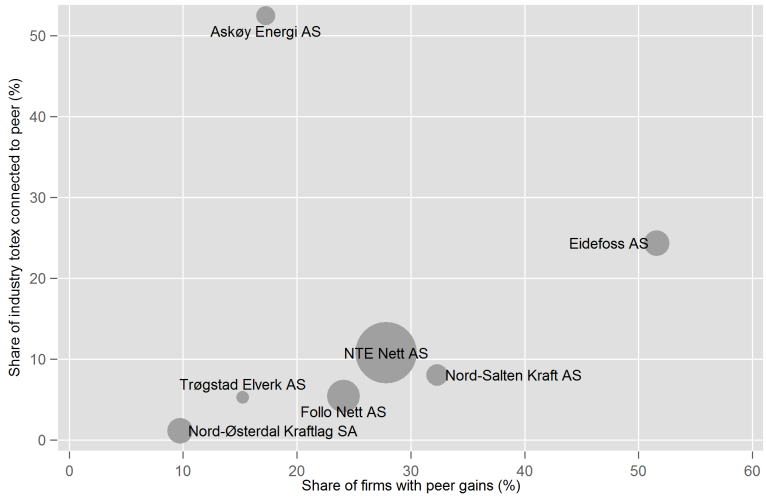
Cross-ownership in Norway 2011-15



Peer effects Norway 2011-15



Peer behaviour

Table 4: Peer behavior ($\xi^t_{k,k}$)

	2011	2012	2013	2014	2015
Askøy Energi AS	90.0	87.7	90.9	91.7	95.2
Eidefoss AS	98.2	97.9	97.3	94.9	92.2
Follo Nett AS	100	100	100	100	99.7
Nord-Salten Kraft AS	88.7	90.8	93.4	94.8	89.4
NTE Nett AS	98.4	97.0	97.8	99.7	100
Nord-Østerdal Kraftlag SA	99.9	100	100	100	100
Trøgstad Elverk AS	94.3	95.8	94.3	92.6	87.6

Peer effects of Norgesnett merger on connected firms

	ω_i^M	$\tilde{\omega}_i^M$
Norgesnett AS	0.96	0.99
Hafslund Nett AS	0.99	0.98
Rakkestad Energi AS	1.00	0.98
Trøgstad Energi AS	1.00	0.98

positive externality on all firms with $\omega < \tilde{\omega}$

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Analysis Norway

Yardstick regulation is effective against collusion, input-mix distortions, end-of-period gaming (ratchet)

Regulation method has become more predictable

- Compact model
- Stable peer firms

Stable frontier (since 1994…)

- Firms may become profitable by innovation (frontier shift)
- Firms may become profitable by strategic mergers (frontier regress)

Empirically 2011-15

- At least one merger had direct positive effects on revenue without any efficiency gains

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Merger gains in regulation

CONCLUSIONS

Conclusions

Regulation must signal correct incentives for mergers ex ante

- The current model can be exploited

Our measure of peer effects complements the decomposition

- Quick calculation to estimate targets (quick wins)
- Tool for ex post review of mergers (revenue effects)

Policy options

- Use distorted information (obfuscation) to increase uncertainty
- Use average-practice methods to limit impact
- Use sanctions for strategic mergers to decrease gains

Main references

Based on:

Agrell, P.J., Teusch, J. (2018) *Strategic behavior under frontier regulation*, submitted paper under review.

Background:

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