Regulatory Path Planning - Introducing Competitive Behaviour in Infrastructure Industries

Current Trends in Competition
Bratislava, 25/10/2017

Prof.dr. Per J. AGRELL
per.agrell@uclouvain.be

Center for Operations Research and Econometrics CORE
Louvain School of Management LSM
This presentation draws on


Outline

Incentive regulation
Dynamic regulation
Contestable regulation
Empirical testing
Discussion
Incentive regulation
Incentive regulation

“…the implementation of rules that encourage a regulated firm to achieve desired goals by granting some, but not complete, discretion to the firm.”

Sappington and Weisman, 1996

Distinguished by partial delegation of pricing to the regulated firm and the possibility for the firm to retain profits resulting from cost reductions.

Vogelsang, 2002

Regulation with intermediate incentive power, as opposed to price-cap regulation and cost of service regulation.

Laffont and Tirole, 1993

(Joskow, 2006)
Incentive regulation in a nutshell

Infrastructure access, unbundled firm, inelastic demand for service
Cost is observable and verifiable, effort is unobservable, multi-output service provision
High-powered regulation is optimal: Laffont (1994), et al.
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
Regulator as proxy buyer or market maker

PROXY BUYER
- Revenue generator
- Full contract
- Market engine
...

MARKET MAKER
- Frame contracts
- Surveillance
- Information verif
....
Two extremes

**PROXY BUYER**
- Cost-oriented
- Ex-post / ex-ante
- Process defined
- Service fuzzy
- Ratchet effects
- No risk
- Perverse incentives for cost
- Deep monopoly structure

**MARKET MAKER**
- Revenue-oriented
- Ex-ante / ex-post
- Process irrelevant
- Service defined
- Risk for quality skimming
- Risk of bankruptcy
- Strong efficiency incentives
- Towards contestable markets
Irrelevance of cost norm

Revenue cap = $R_0 \cdot CPI \cdot (1 - X - X_i)$

Incentive regulation, corollaries
- A profit-maximizing firm does not care about the level of the cap
- A utility-maximizing firm cares about the incentive power
- What matters are the commitment to and duration of the regime
- No importance of the used cost norm
“In deciding how far to revise X the economic regulator needs to examine the company’s production methods and investment programme. He must ascertain the scope for cost and price reductions through increased productivity and efficiency and the need for capital expenditure. He needs to predict the consequences of X on what the company will do, how it will do it, how consumers will be affected and how others will react.”

Littlechild (1983, para 10.2)
### Information

<table>
<thead>
<tr>
<th>Problem</th>
<th>Verifiable</th>
<th>Non-verifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>Contractible</td>
<td>Commitment</td>
</tr>
<tr>
<td>Private</td>
<td>Secrets, signals</td>
<td>Cheap talk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solution</th>
<th>Verifiable</th>
<th>Non-verifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>Complete contract</td>
<td>Renegotiable contracts</td>
</tr>
<tr>
<td>Private</td>
<td>Contingent contracts</td>
<td>Menus of contracts</td>
</tr>
</tbody>
</table>
EU Regulatory landscape (Energy)

Sweden under reform: Rate-of-return regulation

Switzerland under reform: Incentive regulation (DEA pilot)

Iceland: Reform not implemented

Finland: Revenue cap with StonED
Normative models are popular

<table>
<thead>
<tr>
<th>Country</th>
<th>Approach</th>
<th>Method</th>
<th>Analysis</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUSTRALIA</td>
<td>Ex ante</td>
<td>CPI-DEA</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>AUSTRIA</td>
<td>Ex ante</td>
<td>DEA/EngM</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>DENMARK</td>
<td>Ex ante</td>
<td>COLS</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>FINLAND</td>
<td>Ex ante</td>
<td>DEA-&gt;StonED</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>GERMANY</td>
<td>Ex ante</td>
<td>DEA/SFA Yard</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NETHERLANDS</td>
<td>Ex ante</td>
<td>Cost Yard</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NEW ZEELAND</td>
<td>Ex ante</td>
<td>DEA-DEA</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NORWAY</td>
<td>Ex ante</td>
<td>DEA Yard</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ICELAND</td>
<td>Ex ante</td>
<td>CPI-DEA</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>Ex ante</td>
<td>SFA</td>
<td>x</td>
<td>?</td>
</tr>
<tr>
<td>CHILE</td>
<td>Ex ante</td>
<td>EngM</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>SPAIN</td>
<td>Ex ante</td>
<td>EngM</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ENGLAND</td>
<td>Ex ante</td>
<td>CPI-X</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>Ex ante</td>
<td>DEAE-DEA &gt; CR</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>SWITZERLAND</td>
<td>Ex ante</td>
<td>(RoR)-?</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>Ex ante</td>
<td>(EngM)-RoR</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Dynamic regulation
Regulation, industry structure and innovation

Agrell, Bogetoft and Tind (2002)
Regulatory path

Source: Agrell and Bogetoft (2003)
Regulatory path
Example from Norway

Delegation

Cost-plus

Rate of return ex post

CPI-X Ex-ante

Contestable markets

Readiness for multi-utility regulation and contestable markets

Ex-ante rev cap/Ex-post cost yardstick

Ex-post revenue yardstick

Time
Market orientation
Empirical significance

1. Revenue cap CPI-X
   Based on 96/97 productivity estimates
2. Norwegian DEA system (uncapped)
3. Norwegian DEA system (capped)
4. DEA Yardstick

\[
b_t^A (y_t) = c_t + R_0 - c_0 + \rho (c_t E_t^{sr} - c_t^0) \\
\text{allowance} \quad \text{cost sharing} \quad \text{initial profit}
\]
Basic Ideas

Create social welfare gains by better adaptation of costs and benefits
Sub-optimal to treat all areas equally
Gains generated by exploiting differences on the supply and demand sides

*Instead of trying to make everyone happy by the same product, we differentiate the product to take advantage of local demand and cost conditions*

Minor point: May have to forego some social welfare to ensure an appropriate division of the gains (the social welfare cake)
Menus of regulation in the path

Incentive power

Cost-recovery

Rate-of-return

Yardstick regulation

Pseudo-contestable markets

Regulator determines trajectory and regulatory goals

Industry gets some choice in transition speed and profile

higher recovery safety/less incentives

higher incentives/more investment risk

Source: Agrell and Bogetoft (2003)
Menus of regulation: Norway

- **NVE determines trajectory and regulatory goals**

- **Current Ex-ante**
  - Industry gets some choice in transition speed and profile
  - Higher recovery safety/less incentives

- **Ex-post/Ex-ante menus**
  - Higher incentives/more investment risk

- **Ex-post yardstick**
- **Lighthanded ex-post**
  - Readiness for multi-utility regulation and contestable markets
  - NVE decides which stages are open

- **Delegation**

- **Time**
  - Market development
Contestable regulation
Does it hold in practice?

The regulation is based on the cost norm
Regulation must hold for all firms without bias
It is not sufficient to be right on expectation

Judicial recourse to protect from expropriation
- Firms may appeal rulings
- If a ruling shows a flaw in the model, the regime falls
 dbg
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
Credibility

Commitment is based on a rational expectation of durability

The robustness of a regulation depends on

– Participation of the regulated firms
– Sustainability of rents left to stakeholders
– Properties of the cost norm (soundness)

A regulation regime not satisfying these criteria is not credible

“If it sounds too good to be true, it is not true”
Failing regulation in Europe

Netherlands
- Frontier model revoked 2004, debacle 140 M€ in welfare losses
- Nillesen and Pollitt (2007)
- Moratorium and average cost model

Belgium
- Preparation for incentive regulation, overturned and decentralized in 2012
- Agrell and Teusch (2015)
- Cost-plus regulation by region since 2012 …

Sweden
- Network performance assessment model (NAPM) falls in 2006
- Moratorium and cost-plus regulation until 2014 …
Intuition:

- A rational firm reveals only its full efficiency for a regime with a credible commitment and cost norm.

Method:

- Decision model for a firm evaluating a proposed regime
- Methodology to test the hypotheses for firm behavior
- Validation with productivity data for a failed regime
Feasible and infeasible cost norms
Model
One regulated firm
Multi-period game, discount factor
Regulatory regime: $\delta$.
- $R(y)$ = revenue for output $y$
- $x^*(y)$ = minimal cost for output $y$
- $x(y)$ = ex post cost

Firm single-period utility (for given $y$):
- max

$$u(x, R) = (R - wx) + \rho(wx - c(y, w))$$

Slack = lack of effort
Regulatory game

Period 1:
- Launch of high-powered regime \( R(y) \)

Period \( t = 2, \ldots, T \)
- In each period, the regime is challenged
- \( v = P(\text{Regime revoked}) \)
- If not revoked: \( R_t = R(y) \)
- If revoked: cost-plus regime \( R_t = x_{t-1} \)
Game timeline

Figure 1: Dynamic regulation model with failure probability

Figure 2: Critical failure probability \( \hat{v}(d, r) \) for \( d = \{0.99, 0.952, 0.909, 0.667\} \).
Firm’s optimal multi-period policy

\[
EU(x) = \sum_{t=1}^{\infty} u(x, wx)v\delta^t + \sum_{t=2}^{\infty} u(x, wx)v\delta^t(1-v)^{t-1} + \sum_{t=1}^{\infty} u(x, R)\delta^t(1-v)^t \\
= u(x, wx) \left[ \frac{v\delta}{1-\delta} + \frac{v\delta^2(1-v)}{1-\delta(1-v)} \right] + u(x, R)\frac{\delta(1-v)}{1-\delta(1-v)}
\]

Optimal response to credible regime: \( v = 0 \)

\[
EU(x)_{v=0} = (R - wx + \rho(wx - c(y, w)))\frac{\delta}{1-\delta}.
\]

Optimal response to non-credible regime: \( v = 1 \)

\[
EU(x)_{v=1} = \rho(wx - c(y, w))\frac{\delta}{1-\delta}.
\]
Proposition 1:

– The optimal cost policy of a firm in a multi-period policy depends on

1. the probability of regulatory failure (credibility),

2. the time preferences of the firm (impatience) and

3. the utility of inefficient cost (cost of effort).
Corollaries

**Corollary 1.** Assume a given cost of effort \( \rho > 0 \) and discounting factor \( \delta \). Then, there exists a finite failure risk \( \hat{v}(\delta, \rho) \) above which cost-efficiency is a dominated policy.

**Corollary 2.** Assume a non-credible regime \( v > 0 \) and a given cost of effort \( \rho \). Then, for any cost-efficient firm there exists an upper bound \( \hat{\delta} \) for the discount factor.

**Corollary 3.** Assume a non-credible regime \( v > 0 \) and a given discount factor \( \delta \). Then, for any cost-efficient firm there exists an upper bound \( \hat{\rho} \) for the cost of effort.

**Corollary 4.** Assume a non-credible regime \( v > 0 \). The cost efficiency for a firm is then inversely proportional to the discount factor \( \delta \) and the cost of effort \( \rho \).
Remark 1. Given $n$ independent firms each having a cost of effort drawn from a distribution with density function $f(\rho)$ and cumulative density function $F(\rho)$ on the support $[0, 1]$, then the probability that all firms are cost efficient under a non-credible regime is equal to $1 - (F(\hat{\rho}))^n$. 

There will always some laggards …
Figure 1: Dynamic regulation model with failure probability $v$.

Figure 2: Critical failure probability $\hat{v}(\delta, \rho)$ for $\delta = \{0.99, 0.952, 0.909, 0.667\}$. 
VERIFIABLE HYPOTHESES
Research hypotheses

**Hypothesis 1.** Firms exhibit a lower cost efficiency $\text{CE}$ during a non-credible regime $\nu > 0$.

**Hypothesis 2.** The technical change of the firms is stagnating for the duration of a non-credible regime $\nu > 0$.

**Hypothesis 3.** The productivity change of the firms is low or nil for the duration of a non-credible regime $\nu > 0$.

**Hypothesis 4.** The profitability of the firms is lower on average, and decreasing throughout the duration of a non-credible regime $\nu > 0$. 

---

**Table 1**

<table>
<thead>
<tr>
<th>Firm</th>
<th>Ownership</th>
<th>Productivity Change $P$</th>
<th>Technical Change $TC$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birka</td>
<td>Mostly municipal</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>Including interna</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
<tr>
<td>Graninge</td>
<td>Mostly municipal</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
<tr>
<td>EDF</td>
<td>Mostly municipal</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
</tbody>
</table>

---

**Table 2**

<table>
<thead>
<tr>
<th>Firm</th>
<th>Ownership</th>
<th>Cost Efficiency $\text{CE}$</th>
<th>Profitability $\text{PR}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birka</td>
<td>Mostly municipal</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>Including interna</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Graninge</td>
<td>Mostly municipal</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>EDF</td>
<td>Mostly municipal</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

---

**Table 3**

<table>
<thead>
<tr>
<th>Firm</th>
<th>Ownership</th>
<th>Cost Efficiency $\text{CE}$</th>
<th>Profitability $\text{PR}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birka</td>
<td>Mostly municipal</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>Including interna</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Graninge</td>
<td>Mostly municipal</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
<tr>
<td>EDF</td>
<td>Mostly municipal</td>
<td>71.9%</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

---

**Table 4**

<table>
<thead>
<tr>
<th>Firm</th>
<th>Ownership</th>
<th>Productivity Change $P$</th>
<th>Technical Change $TC$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birka</td>
<td>Mostly municipal</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>Including interna</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
<tr>
<td>Graninge</td>
<td>Mostly municipal</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
<tr>
<td>EDF</td>
<td>Mostly municipal</td>
<td>Positive (3.5% per year)</td>
<td>Stagnation</td>
</tr>
</tbody>
</table>
Objective

We are interested in a framework that links

- Profitability changes
- Cost changes
- Revenue changes
- Efficiency changes
Productivity development

Simple approach: efficiency changes vs index?

Not conclusive, since price changes may be due to
- Input price changes (price recovery)
- Output price changes (profit margin)
- Economies of scale (volume)
- Allocative efficiency (mix)
- Technical efficiency changes

Need decomposed analysis
Profitability change

\[
\frac{\Pi^{t+1}}{\Pi^t} = \frac{p^{t+1}y^{t+1}/w^{t+1}x^{t+1}}{p^ty^t/w^tx^t}
\]

Revenue change

Cost change

See Grifell-Tatjé and Lovell (2015b)[Chapters 2-3] for an exhaustive exposition of this firm financial indicator.
Revenue change

\[
\frac{p^{t+1}y^{t+1}}{p^ty^t} = P_F(p^{t+1}, p^t, y^{t+1}, y^t)Y_F(y^{t+1}, y^t, p^{t+1}, p^t),
\]

Fisher output price index

Fisher output quantity index
Cost change

\[
\frac{w^{t+1}x^{t+1}}{w^{t}x^{t}} = \left[ \frac{w^{t+1}x^{t+1}}{w^{t}x^{t}} \right]^{1/2} \left[ \frac{w^{t+1}x^{t+1}}{w^{t}x^{t}} \right]^{1/2} = W_F(w^{t+1}, w^{t}x^{t+1}, x^{t})X_F(x^{t+1}, x^{t}, w^{t+1}, w^{t})
\]

Fisher input price index    Fisher input quantity index
Relative change in profitability

Profitability change
\[
\frac{\Pi^{t+1}}{\Pi^t} = \frac{P_F(p^{t+1}, p^t, y^{t+1}, y^t)}{W_F(w^{t+1}, w^t, x^{t+1}, x^t)} \times \frac{Y_F(y^{t+1}, y^t, p^{t+1}, p^t)}{X_F(x^{t+1}, x^t, w^{t+1}, w^t)}.
\]

Fisher productivity

Fisher productivity index

\[ \frac{Y_F}{X_F} = \Delta CE \cdot \Delta TC \cdot \Delta SC \]

Fisher productivity

Cost efficiency

Technical efficiency

Size change

Efficiency measured using non-parametric approach (DEA)

2 outputs (energy LV, HV)

4 inputs (assetconnections, grid capital, cost OM, energy losses, energy transit)
Empirics: Sweden, electricity distribution

Electricity Act (2000)
- Regulated revenue based on “objective performance”

NPAM (Network Performance Assessment Model)
- Green-field planning model, based on GIS-positioned load points, feed-in points, standard costs
- Critique from industry and academics, model suffers from several methodological flaws (Lantz, 2003; Wennerström and Bertling, 2008; Jamasb and Pollitt, 2008, Jamasb and Söderberg, 2008)
Green-field vs brown-field planning
NPAM rise and fall

2003 Start of implementation
2005 Rulings I for 2003 = 21 DSO for 76,3 MEUR
   – All DSO appeal
2006 Reduced claims for 2003: 8 DSO for 23 MEUR
   – DSO appeal to higher court
2007 New regulator
   – Out-of-court settlement: 8 DSO for 16.5 MEUR.
2009 NPAM suspended (cost-recovery)
2012 New regime: rate-of-return
Data

Audited data from the regulator (EI) for Swedish electricity distributors (LV and MV only, no retail or transmission)
Balanced panel, 128 firms for 2000-2006, in all 896 DMU
Data: DSO 2000-2006

<table>
<thead>
<tr>
<th>Category</th>
<th>Unit</th>
<th>Definition</th>
<th>mean</th>
<th>median</th>
<th>sd</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total revenue</td>
<td>kSEK</td>
<td>Total revenue</td>
<td>137,764</td>
<td>49,967</td>
<td>387,118</td>
</tr>
<tr>
<td>Revenue LV</td>
<td>kSEK</td>
<td>Revenue LV</td>
<td>118,394</td>
<td>41,876</td>
<td>335,470</td>
</tr>
<tr>
<td>Revenue HV</td>
<td>kSEK</td>
<td>Revenue HV</td>
<td>19,371</td>
<td>6,707</td>
<td>53,213</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cost (TOTEX)</td>
<td>kSEK</td>
<td>Total cost (TOTEX)</td>
<td>119,515</td>
<td>46,483</td>
<td>346,036</td>
</tr>
<tr>
<td>Cost transmission</td>
<td>kSEK</td>
<td>Cost transmission</td>
<td>33,791</td>
<td>13,285</td>
<td>100,420</td>
</tr>
<tr>
<td>Cost energy losses</td>
<td>kSEK</td>
<td>Cost energy losses</td>
<td>7,878</td>
<td>2,864</td>
<td>21,395</td>
</tr>
<tr>
<td>Operating expenditure (OPEX)</td>
<td>kSEK</td>
<td>Operating expenditure (OPEX)</td>
<td>46,766</td>
<td>18,615</td>
<td>130,483</td>
</tr>
<tr>
<td>Capital expenditure (CAPEX)</td>
<td>kSEK</td>
<td>Capital expenditure (CAPEX)</td>
<td>31,082</td>
<td>8,602</td>
<td>102,922</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy delivered low voltage (LV)</td>
<td>MWh</td>
<td>Energy delivered low voltage (LV)</td>
<td>488,052</td>
<td>204,662</td>
<td>1,235,396</td>
</tr>
<tr>
<td>Energy delivered high voltage (HV)</td>
<td>MWh</td>
<td>Energy delivered high voltage (HV)</td>
<td>221,633</td>
<td>71,037</td>
<td>623,509</td>
</tr>
<tr>
<td><strong>Output prices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price per energy delivered LV</td>
<td>SEK/kWh</td>
<td>Price per energy delivered LV</td>
<td>0.228</td>
<td>0.226</td>
<td>0.043</td>
</tr>
<tr>
<td>Price per energy delivered HV</td>
<td>SEK/kWh</td>
<td>Price per energy delivered HV</td>
<td>0.109</td>
<td>0.104</td>
<td>0.057</td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy transported, total</td>
<td>MWh</td>
<td>Energy transported, total</td>
<td>742,112</td>
<td>281,796</td>
<td>1,913,920</td>
</tr>
<tr>
<td>Energy losses, total</td>
<td>MWh</td>
<td>Energy losses, total</td>
<td>32,427</td>
<td>11,952</td>
<td>86,027</td>
</tr>
<tr>
<td>Connection-weighted network LV+HV</td>
<td>km</td>
<td>Connection-weighted network LV+HV</td>
<td>41,415</td>
<td>14,198</td>
<td>121,128</td>
</tr>
<tr>
<td>Network capital, total</td>
<td>kSEK</td>
<td>Network capital, total</td>
<td>458,831</td>
<td>100,737</td>
<td>1,521,204</td>
</tr>
<tr>
<td><strong>Input prices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission price</td>
<td>SEK/kWh</td>
<td>Transmission price</td>
<td>0.049</td>
<td>0.048</td>
<td>0.019</td>
</tr>
<tr>
<td>Cost per energy losses</td>
<td>SEK/kWh</td>
<td>Cost per energy losses</td>
<td>0.260</td>
<td>0.252</td>
<td>0.120</td>
</tr>
<tr>
<td>OPEX per connection-line unit</td>
<td>SEK/m</td>
<td>OPEX per connection-line unit</td>
<td>1.379</td>
<td>1.332</td>
<td>0.543</td>
</tr>
<tr>
<td>Cost of capital</td>
<td>%</td>
<td>Cost of capital</td>
<td>0.086</td>
<td>0.083</td>
<td>0.033</td>
</tr>
</tbody>
</table>


Empirical results
H1: Slumping cost efficiency
H4: Profitability sacrifice

Table 2: Profitability $\Pi'$ and cost efficiency $CE'$, mean per year, 2000-2006.

<table>
<thead>
<tr>
<th>year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Pi'$</td>
<td>1.150</td>
<td>1.149</td>
<td>1.141</td>
<td>1.128</td>
<td>1.128</td>
<td>1.086</td>
<td>1.079</td>
</tr>
<tr>
<td>$CE'$</td>
<td>0.762</td>
<td>0.732</td>
<td>0.741</td>
<td>0.732</td>
<td>0.723</td>
<td>0.713</td>
<td>0.708</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>period</th>
<th>2000-02</th>
<th>2003-06</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Pi'$</td>
<td>1.147</td>
<td>1.105</td>
<td>-0.042***</td>
</tr>
<tr>
<td>$CE'$</td>
<td>0.745</td>
<td>0.719</td>
<td>-0.026***</td>
</tr>
</tbody>
</table>

Notes: *** $p < 0.001$; ** $p < 0.05$; * $p < 0.01$. 
H1: Cost efficiency

![Graph showing cost efficiency over time with markers for different years and values like 0.745 and 0.719]
H2: Technical change

Table 3: Cost efficiency $\Delta CE$ and technology change $\Delta TC$, before and after NPAM.

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Pre NPAM</th>
<th>Post NPAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n$</td>
<td>768</td>
<td>384</td>
<td>384</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>$\Delta CE$</td>
<td>0.990</td>
<td>0.065</td>
<td>0.989</td>
</tr>
<tr>
<td>$\Delta TC$</td>
<td>1.024</td>
<td>0.033</td>
<td>1.048</td>
</tr>
</tbody>
</table>

Notes: ***$p$ < 0.001; **$p$ < 0.05; *$p$ < 0.01.
H2: Technical change (before, after)

Table 4: Profitability variation

<table>
<thead>
<tr>
<th></th>
<th>All Pre NPAM</th>
<th>Post NPAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>768</td>
<td>384</td>
</tr>
<tr>
<td>Mean PV</td>
<td>0.994</td>
<td>0.997</td>
</tr>
<tr>
<td>SD PV</td>
<td>0.097</td>
<td>0.080</td>
</tr>
<tr>
<td>Mean PR</td>
<td>0.987</td>
<td>1.001</td>
</tr>
<tr>
<td>SD PR</td>
<td>0.137</td>
<td>0.123</td>
</tr>
<tr>
<td>Mean Productivity change</td>
<td>1.014</td>
<td>1.035</td>
</tr>
<tr>
<td>SD Productivity change</td>
<td>0.084</td>
<td>0.102</td>
</tr>
<tr>
<td>Diff</td>
<td>-0.006</td>
<td>0.028**</td>
</tr>
<tr>
<td>p-value</td>
<td>0.470</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Notes:

*** p < 0.001; ** p < 0.05; * p < 0.01.
H3: Stalled productivity development

Table 4: Profitability variation, price recovery and productivity change, before and after NPAM.

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Pre NPAM</th>
<th>Post NPAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>768</td>
<td>384</td>
<td>384</td>
</tr>
<tr>
<td>Profitability variation</td>
<td>0.994</td>
<td>0.997</td>
<td>0.991</td>
</tr>
<tr>
<td>Price recovery</td>
<td>0.987</td>
<td>0.973</td>
<td>1.001</td>
</tr>
<tr>
<td>Productivity change</td>
<td>1.014</td>
<td>1.035</td>
<td>0.993</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>0.097</td>
<td>0.080</td>
<td>0.111</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>0.080</td>
<td>0.149</td>
<td>0.123</td>
</tr>
<tr>
<td><strong>Diff</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>p-value</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: ***p < 0.001; **p < 0.05; *p < 0.01.
H3: Stalled productivity development
H4: Sacrifice in profitability

Figure 8: Profitability $\Pi^l$, average per DSO, before and after NPAM.
## Results

<table>
<thead>
<tr>
<th>Hypothesis (H)</th>
<th>Result Description</th>
<th>Support Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Cost efficiency slumps for $v &gt; 0$</td>
<td>Supported (***)</td>
</tr>
<tr>
<td>H2</td>
<td>No technical change</td>
<td>Supported (***)</td>
</tr>
<tr>
<td>H3</td>
<td>Productivity change nil or weak</td>
<td>Supported (***)</td>
</tr>
<tr>
<td>H4</td>
<td>Profitability lower and sinking</td>
<td>Supported (***)</td>
</tr>
</tbody>
</table>
Counterfactual?

What if

- The firms just had a ‘golden age’ before, without relevance?
- The shock was unrelated to the regulation?
Supporting evidence

Table 5: Cumulative productivity development, electricity distribution, 1970-2004.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Country</th>
<th>n</th>
<th>Period</th>
<th>M</th>
<th>TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hjalmarsson and Veiderpass (1992)</td>
<td>Sweden</td>
<td>298</td>
<td>1970-78</td>
<td>1.56</td>
<td>1.42</td>
</tr>
<tr>
<td>Kumbhakar and Hjalmarsson (1998)</td>
<td>Sweden</td>
<td>108</td>
<td>1970-90</td>
<td></td>
<td>0.019 - 0.022/yr</td>
</tr>
<tr>
<td>Edvardsen et al. (2006)</td>
<td>Norway</td>
<td>98</td>
<td>1996-03</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>Kumbhakar et al. (2014)</td>
<td>Norway</td>
<td>127</td>
<td>1998-10</td>
<td></td>
<td>0.01/yr</td>
</tr>
<tr>
<td>Miguéis et al. (2011)</td>
<td>Norway</td>
<td>127</td>
<td>2004-07</td>
<td>1.00</td>
<td>1.04</td>
</tr>
</tbody>
</table>

Notes: M = Malmquist index, TC = Technical change, n = average no of obs per year.
Results

Swedish and Norwegian DSO are similar in size, structure and ownership. Efficiency and productivity prior to 2003 are similar in Sweden and Norway. Norway had positive productivity during the NAPM period.
The life vest on Titanic: look beyond inefficiency
Conclusion
Conclusions

Regulation creates conditions for structure and behavior in the sectors
Cost-recovery regulation creates deep distortion of competitive behavior
Incentive regulation creates conditions for cost efficient behavior
Regulation cannot ‘jump stages’: the sector needs a regulatory path
Cost norms must be credible: industry better informed
Two results to retain:
  – Firms may detect flaws earlier than courts
  – Welfare losses proportional to phase-out time
  – Important to choose good models and to integrate them in the path