Economics of Sustainable Networks: Public Engagement and Investment

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About us

• Durham University
• Durham Energy Institute
• Energy Doctoral Training Centre
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  ➢ Wenche Tobiasson
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Public Engagement in Network Development

A New Institutional Economics View
Beauly-Denny Project, Scotland

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Christina Beestermöller
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Economic features of grid development

• Large sunk costs
• Numerous different stakeholders
• Public goods
• Externalities
• Incomplete contracts
• Information asymmetries
Beauly-Denny project: Facts

- High Voltage Transmission line between Beauly, near Inverness, and Denny, near Stirling.
- Ten year planning process between 2002-2012.
- **220km long**, 600 steel pylons between 43 and 65m tall.
- Total Investment: Over £750m.
- Key infrastructural development to connect renewable energy generation in the North to the network.
- Over 20,000 objections from mainly Scotland but also other parts of the world.
- **Longest ever public inquiry in Scotland**.
Theoretical approach: New Institutional Economics

• Neoclassical Economics assumes costless transactions, rational actors and perfect information → Unrealistic

• New Institutional Economics central concepts
  – Transaction cost
  – Property-rights
  – Principal-Agent relationships
  – Market failure

• The concepts are connected through the costs of transacting
  – Uncertainty, opportunism, incomplete contracts, ill-defined property rights and miscommunicated principal-agent relationships increase these costs
Conceptual governance model

• Market based or non-market based
  ➢ Coase (1937), Williamson (1979)

• The optimal (cost minimizing) governance structure determined from the characteristics of a specific activity
## Public engagement

<table>
<thead>
<tr>
<th>Current</th>
<th>Suggested future</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Characterised by one-way communication</td>
<td>- Two-way discussion</td>
</tr>
<tr>
<td>- Limited</td>
<td>- At a place upstream in decision-making process</td>
</tr>
<tr>
<td>- Unstructured</td>
<td>- Integrated non-market based</td>
</tr>
<tr>
<td>- Ineffective downstream in decision-making process</td>
<td>- Clear, uniform framework to limit opportunism, uncertainty, information asymmetry, and thus transaction costs</td>
</tr>
<tr>
<td>- Non-integrated market based</td>
<td>- Increased transparency</td>
</tr>
</tbody>
</table>
Using Supervised Environmental Composites in Production and Efficiency Analyses: An Application to Norwegian Electricity Networks

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University of Cologne
Introduction

- New technologies allow researchers to collect and analyze large amounts of data at relatively low cost.
  - Computational biology, climatology, geology, neurology, health science, economics, and finance.
- Reducing the dimensions of data is a natural and sometimes necessary manner in order to proceed with massive data analyses.
- The action of replacing a set of regressors with a lower-dimensional function is called dimension reduction.
- The reduction is labeled as sufficient or supervised when this reduction is achieved without loss of information (Fisher, 1922).
- Li (1991) introduced the first method for sufficient dimension reduction, i.e. sliced inverse regression (SIR).
  - not used in production economics and efficiency analysis.
• We apply these techniques to a dataset of Norwegian electricity distribution networks, which are regulated using incentive regulation schemes based on efficiency analyses.

• **Weather and geographic conditions** are the most commonly factors perceived to be affecting the performance of electricity networks.

• To reduce the dimensions of the environmental variables we use two supervised methods:
  – SIR = sliced inverse regression
  – PIR = parametric inverse regression.

• We use the most commonly unsupervised method (e.g. PCA) as a benchmark.

• We also examine whether efficiency analyses are robust with respect to using one or other type of methods.
Partial goodness-of-fit

Partial $R^2$

Partial BIC

Number of composites

Number of composites
Investment and Efficiency under Incentive Regulation: Analysis of Norwegian DNOs

Rahmat Poudineh
Tooraj Jamasb
• We use a dataset comprising a balanced panel of 129 distribution companies from 2004 to 2010
• The inputs are capital expenditure ($In$) and other costs ($C_1$)

\[ C_1 = \text{Opex} + \text{Cost of Losses} + \text{Cost of Energy Not Supplied} \]

• The “total number of customers”, “number of substations” and “length of network” are used as outputs
• The parameters used in the model are obtained by maximum likelihood estimation procedure
• All variables are divided by their sample median prior to estimation
Results - Efficiency variation

- Investment has impacted efficiency and in a relatively wide range.

- On average, investments led to 4.8% efficiency gain.
Results - Efficiency gain and loss

- Efficiency loss is prevalent among the companies with lower investment to total cost ratios

- Middle size share of investment created more efficiency gain

- Again high share of investments created less efficiency gain

\[ y = 0.5684x - 0.0879 \]

\[ R^2 = 0.0961 \]
Dynamic Efficiency and Incentive Regulation:
Analysis of Norwegian DNOs

Rahmat Poudineh
Tooraj Jamasb
Dynamic efficiency

• The measure of efficiency obtained in benchmarking is only appropriate for the short run
• Because, it captures the firm’s performance in a snapshot towards its long run equilibrium
• The factors affecting short run behaviour of firm may not adjust instantaneously when the firm invests (e.g., in new technologies or R&D)
• Under this condition, investment may create a virtual inefficiency which persists over time
## Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Simple random effect</th>
<th>Correlated random effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>$\beta_0$</td>
<td>0.34205</td>
<td>(0.053887)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.28762</td>
<td>(0.046698)</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>0.36065</td>
<td>(0.029827)</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>0.24970</td>
<td>(0.036858)</td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>0.09727</td>
<td>(0.038841)</td>
</tr>
<tr>
<td>$\beta_5$</td>
<td>-0.06312</td>
<td>(0.100805)</td>
</tr>
<tr>
<td>$\beta_6$</td>
<td>-0.06084</td>
<td>(0.053950)</td>
</tr>
<tr>
<td>$\beta_7$</td>
<td>-0.02394</td>
<td>(0.072697)</td>
</tr>
<tr>
<td>$\beta_8$</td>
<td>-0.00349</td>
<td>(0.030478)</td>
</tr>
<tr>
<td>$\xi_1$</td>
<td>0.04121</td>
<td>(0.052897)</td>
</tr>
<tr>
<td>$\xi_2$</td>
<td>0.00007</td>
<td>(0.000210)</td>
</tr>
<tr>
<td>$\sigma_v$</td>
<td>0.03418</td>
<td>(0.003877)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.26944</td>
<td>(0.057608)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.76600</td>
<td>(0.038328)</td>
</tr>
<tr>
<td>$\sigma_\nu$</td>
<td>0.24952</td>
<td>(0.027429)</td>
</tr>
<tr>
<td>$\sigma_\omega$</td>
<td>0.12275</td>
<td>(0.010901)</td>
</tr>
</tbody>
</table>

### Long run TE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long run TE</strong></td>
<td><strong>0.75832</strong></td>
</tr>
<tr>
<td><strong>Log likelihood</strong></td>
<td><strong>1071.00</strong></td>
</tr>
<tr>
<td><strong>Posterior probability</strong></td>
<td><strong>0.00000</strong></td>
</tr>
</tbody>
</table>
Conclusions

• 76% of ratio of inefficiency is transmitted to the subsequent periods
• This arises because of technological difference among firms or cyclical investments
• This effect of sluggish adjustment of output is problematic for companies' revenue under ex-post regulatory treatment of investment
• Thus, inclusion of capital cost in benchmarking model might result in unintended outcome for investment and innovation behaviour of distribution companies
Determinates of Investments:
Analysis of Norwegian DNOs

Rahmat Poudineh
Tooraj Jamasp
Methodology

• Due to the uncertainty around the response of the firm to different incentive instruments we adopt a Bayesian Model Averaging (BMA) technique

• BMA is a powerful tool to examine the extent to which any given factor improves the explanatory power of the estimated models when it is included

• It takes into account the uncertainties around model selection and estimation
<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th>Name</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent</td>
<td>Investment*</td>
<td>IN</td>
<td>74</td>
<td>337124</td>
<td>22003</td>
</tr>
<tr>
<td>Group 1: Demand factors</td>
<td>Energy density (MWh/KM)</td>
<td>DENS</td>
<td>137</td>
<td>2234</td>
<td>546</td>
</tr>
<tr>
<td></td>
<td>Number of stations (#)</td>
<td>NS</td>
<td>29</td>
<td>14405</td>
<td>993</td>
</tr>
<tr>
<td></td>
<td>Number of customers(#)</td>
<td>NC</td>
<td>243</td>
<td>535443</td>
<td>19869</td>
</tr>
<tr>
<td></td>
<td>Number of leisure home (#)</td>
<td>RE</td>
<td>68</td>
<td>27307</td>
<td>2279</td>
</tr>
<tr>
<td></td>
<td>Distributed generation (MW)</td>
<td>DG</td>
<td>0</td>
<td>96</td>
<td>10</td>
</tr>
<tr>
<td>Group 2: Quality factors</td>
<td>Cost of energy not supplied*</td>
<td>CENS</td>
<td>12</td>
<td>58527</td>
<td>2928</td>
</tr>
<tr>
<td></td>
<td>Cost of network energy loss*</td>
<td>CNEL</td>
<td>278</td>
<td>394127</td>
<td>14949</td>
</tr>
<tr>
<td>Group 3: Environmental factors</td>
<td>Share of overhead lines (%)</td>
<td>OH</td>
<td>0.13</td>
<td>0.97</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Snow condition (millimetres)</td>
<td>snow</td>
<td>53</td>
<td>1194</td>
<td>367</td>
</tr>
<tr>
<td></td>
<td>Wind and distance to coast (ratio)</td>
<td>wind</td>
<td>0</td>
<td>0.16</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>Forest productivity (fraction)</td>
<td>forest</td>
<td>0</td>
<td>0.55</td>
<td>0.16</td>
</tr>
<tr>
<td>Group 4: Other factors</td>
<td>Depreciation*</td>
<td>DEP</td>
<td>631</td>
<td>281978</td>
<td>16606</td>
</tr>
<tr>
<td></td>
<td>Operational expenditure*</td>
<td>OPEX</td>
<td>878</td>
<td>854646</td>
<td>45136</td>
</tr>
</tbody>
</table>
Posterior inclusion probability
Conclusions

• Depreciations, number of leisure homes, number of transformers, energy density, and cost of energy not supplied are main drivers of investments

• No evidence of environmental factors driving investments
• No investment effect from distributed generation sources

• Cost of network energy loss also had no impact on investments
• Possibly, because of different treatment of cost of network energy loss and quality of service