Economies of scope and scale in the electricity industry

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Economies of scope

• Positive economies of scope means that the costs of producing two outputs are lower compared to a situation where two separate firms produce one output each.

• Distribution and Generation of electricity.

• **Research question**: What are the costs and/or benefits of strict separation of the integrated firms?
The electricity industry has undergone changes in Norway as in the rest of the world.
- Policy makers wish to unbundle vertical integrated firms, and the main motivations are:
  - Increase competition in the market
  - Avoid cross-subsidization
  - Make distribution system operators (DSOs) focus on network operations only

In 2016, the Norwegian Parliament amended the Energy Act, with changes taking effect from 2019. Strict separation of all generation- and distribution companies.
- This policy comes with a cost of not utilize economies of scope (if present)
  - How high are these costs?
- New data from Norway makes it possible to answer this question
Høring av endringer i energiloven om krav til selskapsmessig og funksjonell skille.

At kjemper som BKK skulker de mindre aktørene, er lite ønskelig.

Det er flere tiltak konsolideringen har å regne med. Streng Velken i BKK er det eneste i Norge med slike tiltak.

 Sending regningen på 4,6 milliarder til nettkundene

Vi er fullt imot, sier regjeringen. Kontakta dem for mer informasjon.

ENERGI NORGES SNUR I SAKEN OM FUNKSJONELL SKILLE

Ose omtaler at nettselskapene i forloven er svært opprørt over Energi Norges håndtering av saken. Sakter at det funksjonelle skillet avtatt er.

Rapport fra Varde Hartmark viser at Regjeringens funksjonelt skille vil koste nærmere fem milliarder kroner.
Table 1. Summary of previous empirical scope- and scale studies of the combined generation and transmission/distribution electricity companies.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Data</th>
<th>Functional form</th>
<th>Est. method</th>
<th>Economies of scope and scale*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaserman and Mayo</td>
<td>Cross-section (1981, US)</td>
<td>Quadratic cost function</td>
<td>OLS</td>
<td>Economies of scope (EOS) = 0.12 (at mean)</td>
</tr>
</tbody>
</table>

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</thead>
<tbody>
<tr>
<td>Arceci et al. (2012)</td>
<td>Cross-section (2001, US)</td>
<td>Quadratic cost function together with cost share equations</td>
<td>SUR</td>
<td>EOS = 0.04 – 0.10. RTS = 1.01 - 1.03. Reports: positive sample mean estimates of both vertical and horizontal economies.</td>
</tr>
<tr>
<td>Meyer (2012a)</td>
<td>Panel-data (2001-2008, US)</td>
<td>Quadratic cost function</td>
<td>OLS</td>
<td>EOS = 0.19 - 0.26, when separating generation from distribution and retail. Reports: if generation and transmission remain integrated but are separated from distribution and retail, EOS = 0.08 – 0.10.</td>
</tr>
<tr>
<td>Trebos et al. (2016)</td>
<td>Panel-data (2000-2003, US)</td>
<td>Flexible technology translog cost functions with different specifications</td>
<td>SUR</td>
<td>EOS = 0.04 (0.40 when zeros are replaced by small numbers in the common cost function model). RTS = 1.10 – 1.13. Reports evidence of economies of scale and vertical economies of scope.</td>
</tr>
</tbody>
</table>

*Estimates of economies of scale (measured by return to scale (RTS)) are for integrated firm.
DATA

- The data comprise economic and technical information on Norwegian electricity firms from 2004 to 2014
- Data collected by the Norwegian Water Resources and Energy Directorate (NVE)
- Model specifications:
  - Two outputs/products: Distribution (D) km network and Generation (G) in Mwh
  - One input: Total costs (C)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Min</th>
<th>Median</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs (1,000 NOK):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated firms (distribution and generation)</td>
<td>31,251</td>
<td>31,663</td>
<td>2,255</td>
<td>20,677</td>
<td>199,678</td>
</tr>
<tr>
<td>Specialized firms (distribution)</td>
<td>30,202</td>
<td>36,520</td>
<td>4,125</td>
<td>16,399</td>
<td>274,822</td>
</tr>
<tr>
<td>Specialized firms (generation)</td>
<td>17,385</td>
<td>21,480</td>
<td>27</td>
<td>10,504</td>
<td>175,552</td>
</tr>
<tr>
<td>Outputs:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution, km network</td>
<td>307</td>
<td>430</td>
<td>0</td>
<td>172</td>
<td>2,010</td>
</tr>
<tr>
<td>Generation, Mwh</td>
<td>103,850</td>
<td>203,767</td>
<td>0 (2,319)</td>
<td>14,640</td>
<td>1,081,640</td>
</tr>
<tr>
<td>Year</td>
<td>2004</td>
<td>2014</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time dummies:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Td1 (2004 – 2005)</td>
<td>371</td>
<td>104</td>
<td>142</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>Td3 (2008 – 2009)</td>
<td>386</td>
<td>101</td>
<td>138</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Td4 (2010–2011)</td>
<td>381</td>
<td>94</td>
<td>112</td>
<td>148</td>
<td></td>
</tr>
<tr>
<td>Td5 (2012–2013)</td>
<td>300</td>
<td>94</td>
<td>134</td>
<td>72</td>
<td></td>
</tr>
</tbody>
</table>

**Firm type observations:**
- Integrated firms (distribution and generation): 515 observations, 55 firms
- Specialized firms (distribution): 707 observations, 80 firms
- Specialized firms (generation): 651 observations, 126 firms
- Total firms: 1,883 observations, 261 firms

Note: Numbers in parentheses are the minimum positive outputs for distribution and generation.
Vi estimate three different random effects models in our analysis

- **Modell 1**: «Normal» specification of a quadratic cost function
  - All firm types; specialized in generation, specialized in distribution and integrated firm with both generation and distribution are assumed to have equal technology.
  - Not possible to test.

- **Modell 2**: Dummy variable specification of quadratic cost function that allows different types of technology
  - Possible to test.

- **Modell 3**: Same as Modell 2, but with translog cost function.
Scope measure

$$\text{Scope} = \frac{(C_D(D, 0) + C_G(0, G)) - C_I(D, G)}{C_I(D, G)}$$

- > 0, Economies of scope from integrated firms
- < 0, Diseconomies of scope from integrated firms
RESULTS
-Scope and Scale

• All actual output combinations for the 515 firm observations from the 55 integrated firms over an eleven-year period in our panel data are used.

• Total costs increases by 3% if we separate distribution and generation.

• Increase the cost for integrated firms with 3% \( \rightarrow 31,231 \times 0.03 \times 55 \text{ firms} = 51,531 \rightarrow \text{NPV (10 year)} = 372,187 \)

• Increase the cost for integrated firms with 23% \( \rightarrow 31,231 \times 0.23 \times 55 \text{ firms} = 395,072 \rightarrow \text{NPV (10 year)} = 2,831,776 \)

• Economies of scale estimates correspond to earlier results on Norwegian data Mydland et al. (2016) and Kumbhakar et al. (2015)

\[
\text{Scope} = \frac{(C_D(D, 0) + C_G(0, G)) - C_I(D, G)}{C_I(D, G)}
\]

Table 4. Economies of scope and scale results from the three models

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Economies of scope</th>
<th>Economies of scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>1%</td>
<td>0.09</td>
<td>-0.02</td>
</tr>
<tr>
<td>5%</td>
<td>0.10</td>
<td>0.01</td>
</tr>
<tr>
<td>10%</td>
<td>0.12</td>
<td>0.03</td>
</tr>
<tr>
<td>25%</td>
<td>0.16</td>
<td>0.09</td>
</tr>
<tr>
<td>Median</td>
<td>0.23</td>
<td>0.18</td>
</tr>
<tr>
<td>75%</td>
<td>0.30</td>
<td>0.32</td>
</tr>
<tr>
<td>90%</td>
<td>0.40</td>
<td>0.48</td>
</tr>
<tr>
<td>95%</td>
<td>0.46</td>
<td>0.61</td>
</tr>
<tr>
<td>99%</td>
<td>0.74</td>
<td>0.92</td>
</tr>
</tbody>
</table>

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COMPARING RESULTS

- Plots of economies of scope related to firm size (measured as total costs) for each of the integrated firms.

- For Model 1 and Model 2, there is a clear relationship between firm size and economies of scope.

- Model 3: negative, but no clear trend.
Economies of scope
- Geographic presentation of results from Model 2
CONCLUSIONS

• Overall we find economies of scope from integrated firms

• The economies of scope are highest for the smallest firms and is decreasing with firm size. Some of the bigger firms have diseconomies of scope.

• In Model 1 and Model 2 we find a clear relationship between economies of scope and firm size. In Model 3 there are no clear relationship. We see a negative trend but even for the smallest companies (low total costs) we find both economies- and diseconomies of scope.

• Idea for further work
  • Will the cost of unexploited economies of scope be offset by gains from economies of scale?
    • Combine scope and merger analysis.
    • Merge companies with high scope estimates ...
Economies of scope
-Furter work

- So far our findings show evidence of economies of scope and economies of scale.

- The amendment of the Norwegian Energy act (Energiloven § 4-6 og § 4-7) which ensure strict separation of the firm types will increase costs by not utilize economies of scope.

- New analyze / research question:
  - New scope-study, with some adjustments
  - Include merger gains i analysen

- Research question:
  - Can the merger gains offset the increase in total cost from not utilizing economies of scope?
    - Merger analyze:
      - Geographical?
      - Based on scope results?
      - Who keeps the gains/winnings?


Questions