Incentive Regulation and Investment Behavior

Evidence from the German Electricity Distribution Sector

Selected results from a study on behalf of Federal Network Agency (BNetzA)

Conference on Applied Infrastructure Research (Infraday 2014)
09. Oktober 2014, TU Berlin

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Background and research questions

- Incentive regulations determines revenue caps of energy system operators in Germany since 2009
  - Objective: cost efficiency
- Influence of incentive regulations on investment incentives is unclear (particularly relevant in the context of the “Energiewende”)

- Research questions:
  - Is it possible to identify relevant impact factors on investment behaviour of system operators?
  - What about differences by type of system operator (i.e. DSOs vs. TSOs, electricity vs. Gas)?
  - Does the introduction of incentive regulation in 2009 have an impact on investment behaviour?
Main findings

- Assessment of impact factors on the system operators’ investment behaviour and the impact of incentive regulation on investment behaviour require extensive empirical analyses (-> multivariate regressions)!
- Data base available for this study is a good starting point for analysing investment behaviour of DSOs:
  - No indication for negative impact of the introduction of incentive regulation on investments during analysed period
  - Significant positive correlation between the introduction of incentive regulations (in 2009) and investments.
- For TSOs, available data does only allow for descriptive analyses of key indicators.
  - Analyses show no indication for structural interruptions in the investment behaviour before/after 2009!
Starting point: theory and literature (i)

From a theoretical perspective, the impact of incentive regulation on investment behaviour is ambiguous. Rather, specific regulatory design is of crucial importance.

(-) shifting investment risks away from final consumers lowers investment incentives of system operators (Egert 2009)
(-) focus on realising short-term efficiency gains can distract from securing quality of supply through (replacement) investments (Burns and Riechmann 2004).
(+ ) stronger incentives for investments in cost-reducing technologies (Egert 2009)

Possible barriers to investment due to the design of regulation, e.g.
(-) unrealistic or ex post revisions of requirements (Egert 2009)
(-) delay of investment reflux (Brunekreeft 2011)

➢ Definite answers only possible on case by case basis and derived from empirical analyses!
Starting point: theory and literature (ii)

Empirical literature does not identify systematic negative impact of incentive regulation on investment incentives in energy supply.

Empirics

(+) telecommunication (USA): Significant impact of incentive regulation (price-cap) on investments in new technologies (Ai and Sappington 2002; Greenstein et al. 1995)

(+) electricity DSOs (GB): Higher productivity and service quality after implementation of incentive regulation (Newbery and Pollitt, 1997; Domah and Pollitt, 2004)

(+) energy supply (23 biggest companies in Germany, Italy, Spain and UK): Implementation of incentive regulation has significant positive impact on investments (Cambini and Rondi, 2009)

But: limited number of empirical studies due to extensive data requirements

➢ Our analysis contributes in this context!
Data set: representative sample of the 1500 system operators in Germany

- Adequate size to represent the heterogeneity in the population:
  - TSOs (complete due to small number)
  - DSOs: separately for electricity and gas and stratified by net-related total costs (→ size)
  - Number of strata as well as sample size (total and per stratum) determined by statistical criteria:

<table>
<thead>
<tr>
<th></th>
<th>Electricity</th>
<th>Gas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSOs</td>
<td>4</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>DSOs</td>
<td>109</td>
<td>68</td>
<td>177</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>80</td>
<td>193</td>
</tr>
</tbody>
</table>

- Data collected by Federal Network Agency by end of 2013
Available information

- Relevant information from:
  - Balance sheets (2006-2012)
  - Profit/loss statements (GuV, 2006-2012)
  - Tangible fixed assets (historic prices/costs, 1960-2012)
  - Structural parameters (2006-2012)
  - Maintenance- und Asset-management
  - Investment management
  - Concessions and changes in concessions

- Supplementary information on the individual system operators:
  - Efficiency score
  - Quality indicators (SAIDI, ASIDI, etc.)
  - GDP (national and regional levels based on respective district of the system operators)
Quantifying investments & investment behaviour

- **Investments**
  - Calculated on basis of balance sheet and profit/loss statements (following commercial law)
  - Calculated on basis of tangible fixed assets at historic and current prices/costs

- **Investment ratio**
  Investments as a share in tangible fixed assets (based on either commercial law or cost-accounting)

- **Re-Investment ratio**
  Investments as a share of depreciation (based on either commercial law or cost-accounting)
Identifying the impact of incentive regulation

- **Before - after:**
  - Impact on investments before and after the implementation of incentive regulation (2006-2008 vs. 2009-2012)

- Impact on investments **by type of regulation:**
  - Operators under regular or simplified procedure

- **Limitation:**
  - Causal relationship between incentive regulation and investment behaviour not clearly identifiable due to missing counterfactual (- all DSOs subject to incentive regulation since 2009)
Investments
(mean of all DSOs in mio. Euro)

Remark:
Calculated on basis of tangible fixed assets.
Investment ratio
(mean of all DSOs, in %)

Investment ratio = \left( \frac{\text{Investment}}{\text{tangible fixed assets}} \right) \times 100

Remarks:
- Calculated on basis of tangible fixed assets at current prices/costs
- Small number of observations due to data cleansing
Analytical approach

- Econometric regression analysis based on existing empirical literature

- Basic model derived from microeconomic literature on investment behaviour at the company level
  - Trade-off between explanatory power of the model and the number of variables

- Extensions of the basic model to include specific factors relevant for energy system operators
Structure of estimation model

- **Investment ratio**
  - **Basic model**
    - General impact factors
  - **Extension i**
    - Additional factors relevant for energy system operators
  - **Extension ii**
    - Regulation

- $f(\cdot)$
  - Investments ratio of previous periods
  - Demand
  - Etc.

- $f(\cdot)$
  - Type of system operator
  - Structural characteristics
  - State of facilities
  - Quality of supply
  - Type of ownership
  - Rentability
  - Depreciation

- $f(\cdot)$
  - Incentive regulation
Selection of estimation procedure

- **Challenge**: interdependent relationship between exogenous and endogenous variables (e.g. autocorrelation w.r.t. investments or endogenous relationship between investments and the state of facilities)
- **Consequence**: standard estimation procedures (e.g. OLS or Fixed Effects) yield biased results
- **Solution**: GMM (Generalized Method of Moments) as alternative estimation procedure
  - Estimation based on instruments
  - Produces unbiased results (Hansen 1982)
- **Trade-off**: GMM requires a large sample size
  → Possibly problems with estimation of sub-groups (e.g. private DSOs)
Results of multivariate estimation: Basic model for electricity DSOs

**Dependent variable:** Investment ratio of electricity distribution service companies

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment ratio of previous period</td>
<td>0.846</td>
<td>0.0710</td>
<td>0.000</td>
</tr>
<tr>
<td>GDP of previous period (national)</td>
<td>-5.2331</td>
<td>1.1652</td>
<td>0.000</td>
</tr>
<tr>
<td>Small system operator (&lt; 30,000 customers)</td>
<td>0.1032</td>
<td>0.0483</td>
<td>0.033</td>
</tr>
<tr>
<td>Area supplied LV</td>
<td>0.0594</td>
<td>0.0273</td>
<td>0.030</td>
</tr>
<tr>
<td>Number of connection points LV</td>
<td>-0.0535</td>
<td>0.0223</td>
<td>0.016</td>
</tr>
<tr>
<td>Geographical area MV</td>
<td>-0.0239</td>
<td>0.0207</td>
<td>0.248</td>
</tr>
<tr>
<td>Number of connection points MV</td>
<td>0.0269</td>
<td>0.0178</td>
<td>0.132</td>
</tr>
<tr>
<td>Constant</td>
<td>24.3790</td>
<td>5.4478</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Negative sign caused by overlap with effect of incentive regulation (see next slides)

Consistent with negative correlation with density (connection points per area LV)
Results of multivariate estimation: Basic model for gas DSOs

**Dependent variable:** Investment ratio ($r_{it}$) at current prices/costs

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment ratio of previous period</td>
<td>0.8099</td>
<td>0.1527</td>
<td>0.000</td>
</tr>
<tr>
<td>GDP of previous period (regional)</td>
<td>-0.0687</td>
<td>0.0409</td>
<td>0.093</td>
</tr>
<tr>
<td>Small system operator (&lt; 15,000 customers)</td>
<td>0.2098</td>
<td>0.1062</td>
<td>0.048</td>
</tr>
<tr>
<td>Location in Neue Bundesländer</td>
<td>0.1879</td>
<td>0.1045</td>
<td>0.072</td>
</tr>
<tr>
<td>Number of connection points</td>
<td>0.1744</td>
<td>0.0602</td>
<td>0.004</td>
</tr>
<tr>
<td>Area supplied</td>
<td>-0.0830</td>
<td>0.0276</td>
<td>0.003</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.2243</td>
<td>0.0979</td>
<td>0.022</td>
</tr>
</tbody>
</table>

Negatives sign signals impact of customer segments

Consistent with positive correlation with density (connection points per area supplied)
Results of multivariate estimation: Incentive regulation (DSOs)

<table>
<thead>
<tr>
<th>Dependent variable: Investment ratio(_{it}) at current prices/costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic model plus…</td>
</tr>
<tr>
<td>…implementation of the incentive regulation:</td>
</tr>
<tr>
<td>- Implementation since 2009</td>
</tr>
<tr>
<td>- Efficiency score in RP1</td>
</tr>
<tr>
<td>… design of the incentive regulation:</td>
</tr>
<tr>
<td>- Effects specific to each year</td>
</tr>
<tr>
<td>- Base years</td>
</tr>
<tr>
<td>- Participation in simplified procedure</td>
</tr>
<tr>
<td>Explanation:</td>
</tr>
</tbody>
</table>

Explanation:

+++ (---) positive (negative) correlation on a 1%-level of significance
++ (-- ) positive (negative) correlation on a 5%- level of significance
+ (- ) positive (negative) correlation on a 10%- level of significance
0 no significant correlation
Results of multivariate estimation: Change in supply duties (DSOs)

**Dependent variable:** Investment ratio($i_t$) at current prices/costs

**Basic model plus…**

**Installed capacity of decentralised generation:**
- Annual rate of change LV: 0
- Annual rate of change MV: 0
- Annual rate of change HV: +++
- Annual rate of change LV/MV: 0
- Annual rate of change MV/HV: 0

**No significant impact found for:**
- Changes of supplied area (all voltage levels)
- Number of EEG-Installations (all voltage levels)
Conclusions

- Investment behaviour dependent on type of system operator (electricity, gas, size, density etc.)
- Not all effects can be clearly identified (overlaps e.g. for size effects and simplified procedures or public property and VNBs gas in new German states)
- Incentive regulation has a significantly positive effect on investments:
  - Strong base year effect for electricity DSOs: average investment ratios in 2010 and 2011 significantly higher than before 2009
  - Base year effect also for Gas DSOs: average investment ratios in 2009 and 2010 significantly higher than before 2009 (but result is not as robust as for electricity DSOs)
- Changes in the supply duties do have impact on investment behaviour, but do not explain the increases of investment ratios in the base years of incentive regulation
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