

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*

*Astrid Cullmann & Maria Nieswand (DIW Berlin)
Ferdinand Pavel (DIW Econ)*

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.

Theory

- (-) 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:

	Electricity	Gas	Total
TSOs	4	12	16
DSOs	109	68	177
Total	113	80	193

- 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)

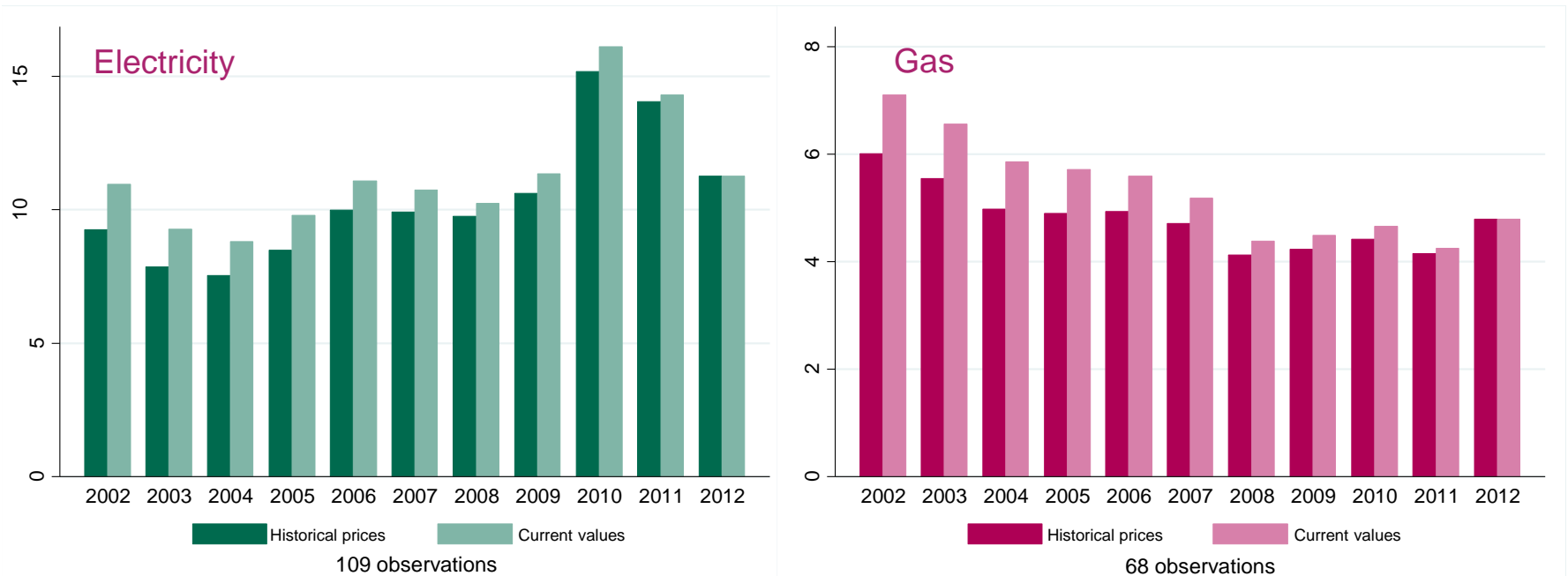
Identifying the impact of incentive regulation

- **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)

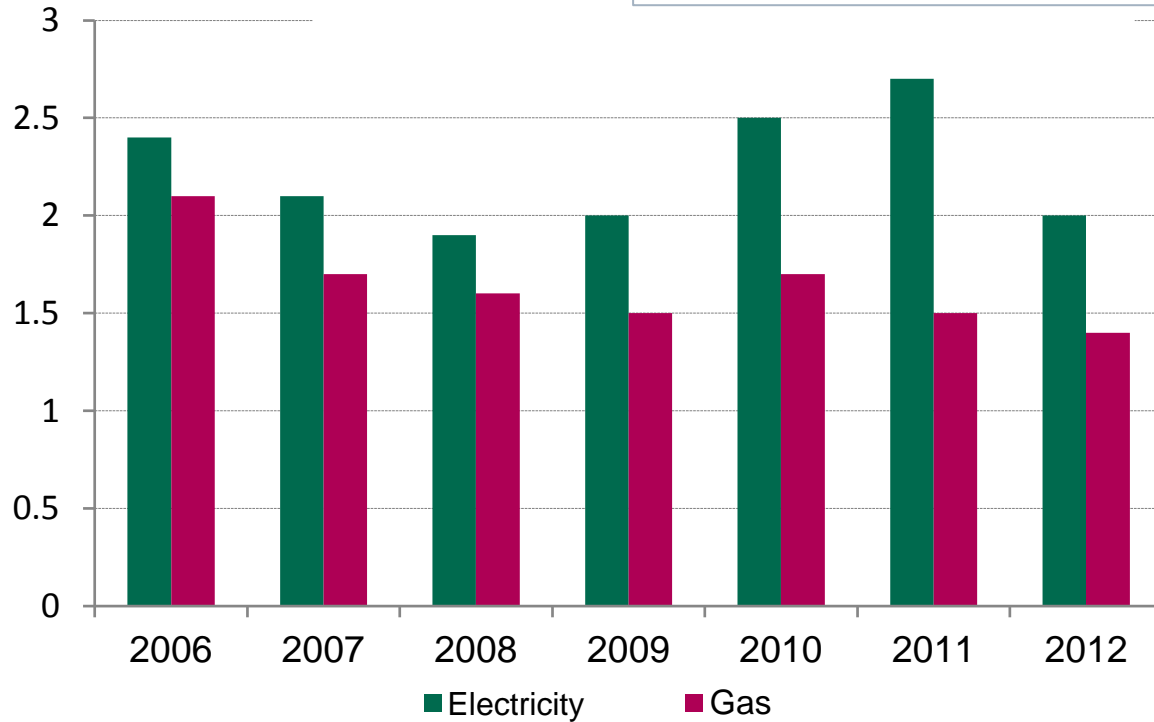
Investments (mean of all DSOs in mio. Euro)



Remark:
Calculated on basis of tangible fixed assets.

Investment ratio (mean of all DSOs, in %)

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



101 observations 65 observations

Remarks:

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

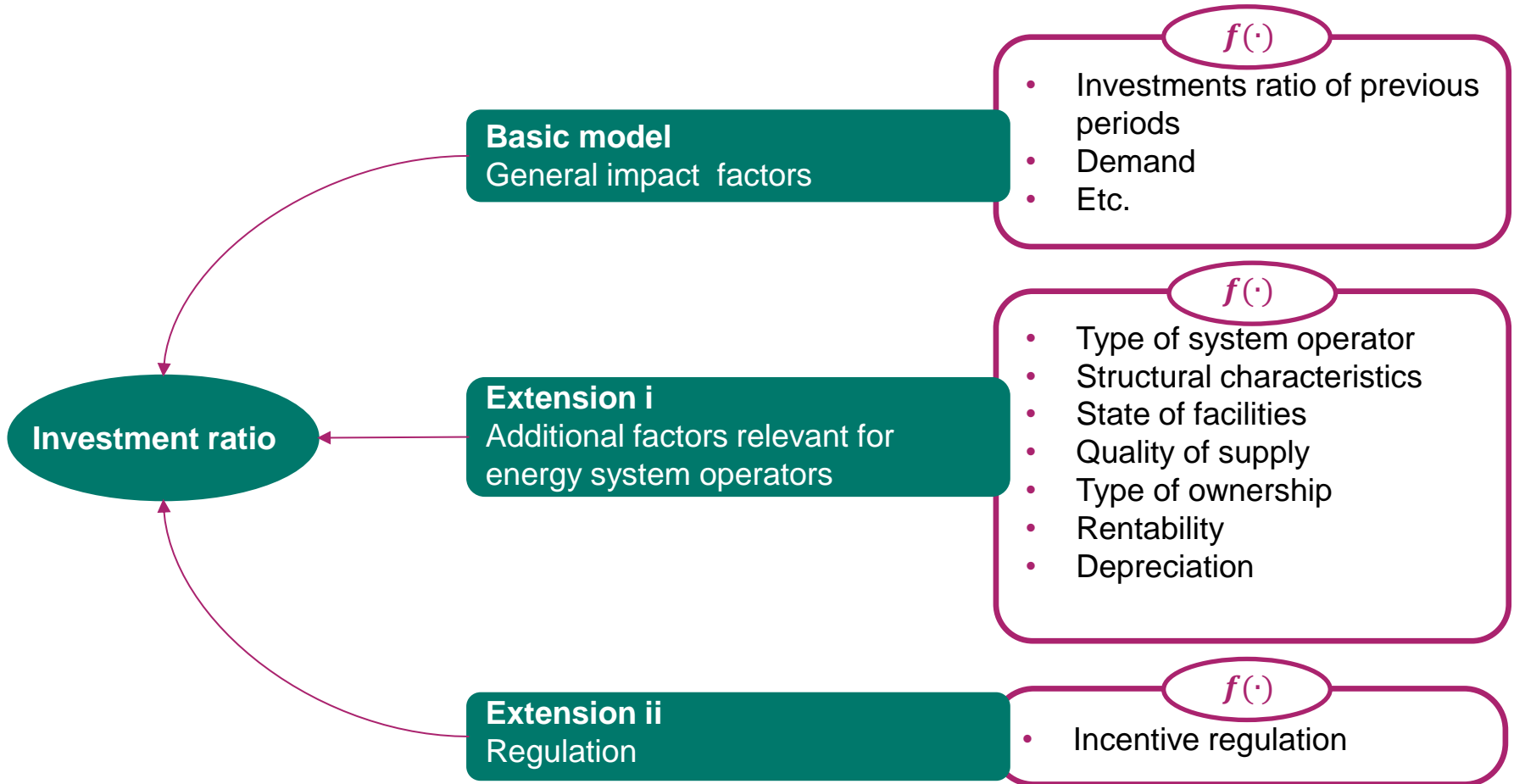
Analytical approach

- Econometric regression analysis based on existing empirical literature
 - Cambini and Rondi (2010, 2011), Bortolotti, Cambini and Rondi (2013), Lyon and Mayo (2005), Egert (2009), Spiegel and Spulber (1994)

- 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



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(i_t) at current prices/costs

Independent variables	Coefficient	Standard Error	P-value	
Investment ratio of previous period	0.846	0.0710	0.000	***
GDP of previous period (national)	- 5.2331	1.1652	0.000	***
Small system operator (< 30.000 customers)	0.1032	0.0483	0.033	**
Area supplied LV	0.0594	0.0273	0.030	**
Number of connection points LV	-0.0535	0.0223	0.016	**
Geographical area MV	-0.0239	0.0207	0.248	
Number of connection points MV	0.0269	0.0178	0.132	
Constant	24.3790	5.4478	0.000	***

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(i_t) at current prices/costs

Independent variables	Coefficient	Standard Error	P-value	
Investment ratio of previous period	0.8099	0.1527	0.000	***
GDP of previous period (regional)	-0.0687	0.0409	0.093	*
Small system operator (< 15.000 customers)	0.2098	0.1062	0.048	**
Location in <i>Neue Bundesländer</i>	0.1879	0.1045	0.072	*
Number of connection points	0.1744	0.0602	0.004	***
Area supplied	-0.0830	0.0276	0.003	***
Constant	-0.2243	0:0979	0.022	**

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)

	Electricity	Gas
<u>Dependent variable:</u> Investment ratio _(it) at current prices/costs		
<i>Basic model plus...</i>		
<i>...implementation of the incentive regulation:</i>		
- Implementation since 2009	+	0
- Efficiency score in RP1	++	0
<i>... design of the incentive regulation:</i>		
- Effects specific to each year	+++ (2010)	0
- Base years	+++	(+)
- Participation in simplified procedure	++	++
	possibly size effect	possibly size effect

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_(it) 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

Contact



Dr. Ferdinand Pavel
Manager
DIW Econ GmbH • Mohrenstraße 58
10117 Berlin • Germany

Tel. +49.30.20 60 972 0
Fax. +49.30.20 60 972 99
E-mail: fpavel@diw-econ.de
URL: www.diw-econ.com

Registered Association based in Berlin, Germany, Court of Registry: Amtsgericht Berlin-Charlottenburg, HRB 108699 B