

# **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.

### 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**

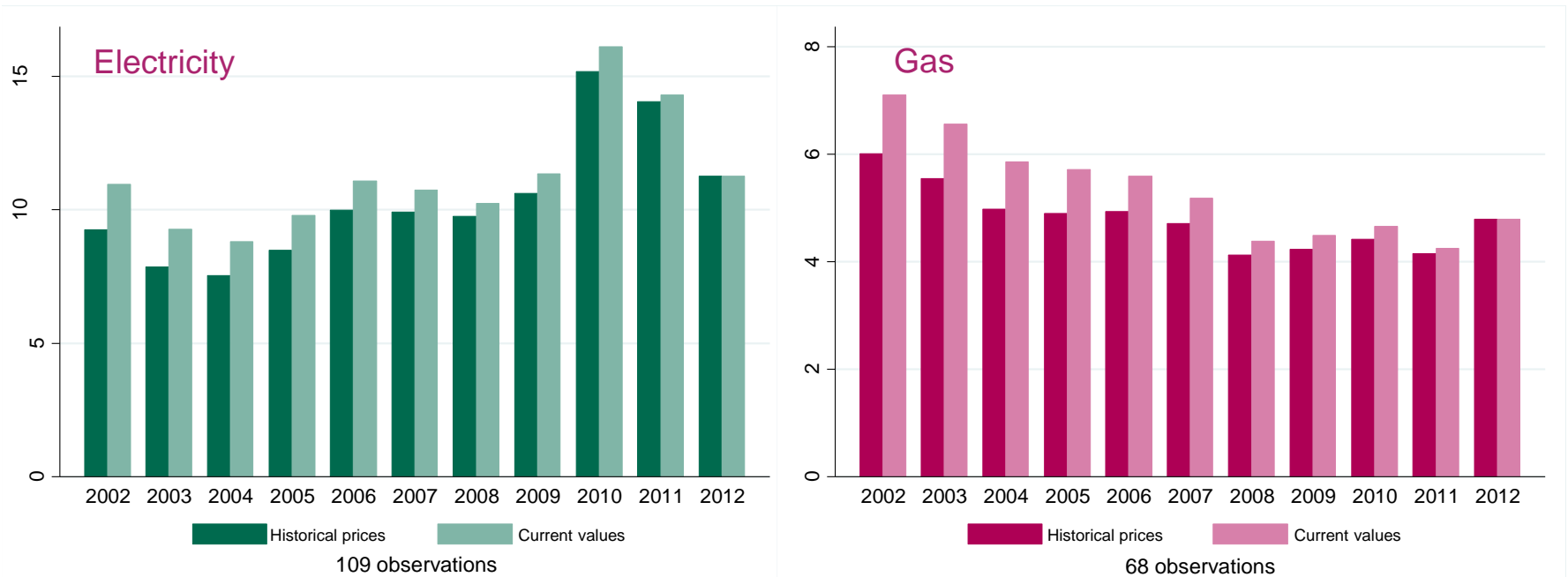
Investments as a share of depreciation  
(based on either commercial law or cost-accounting)



## 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)

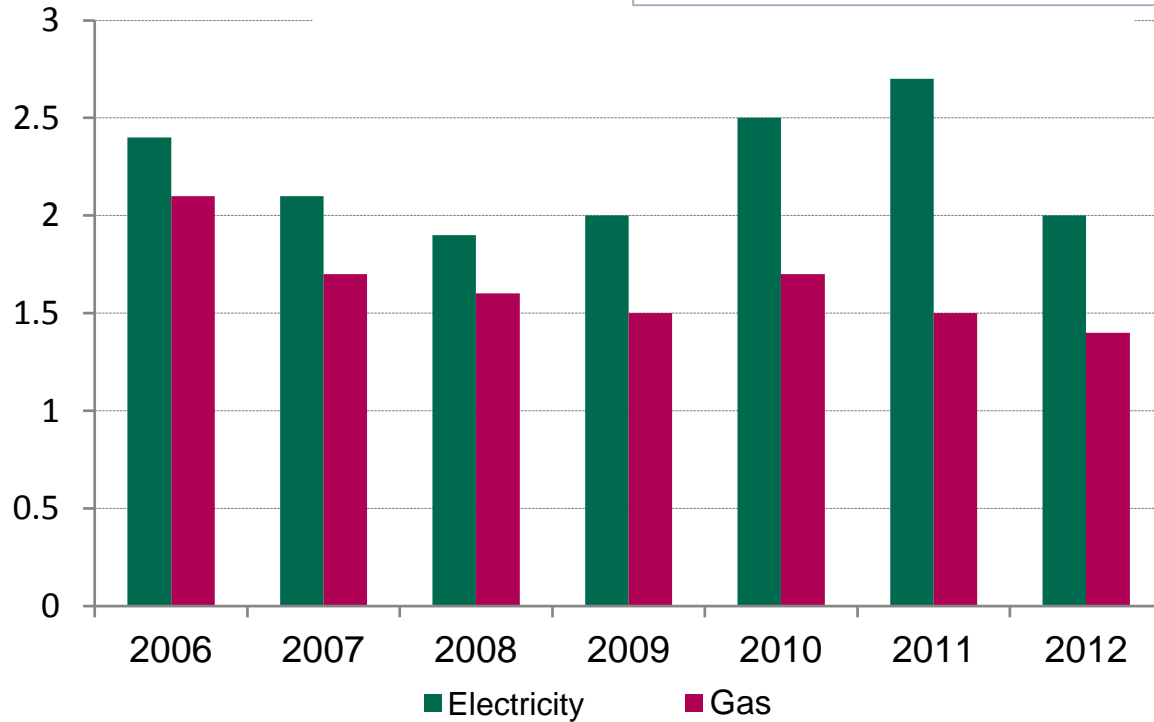
# Investments (mean of all DSOs in mio. Euro)



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

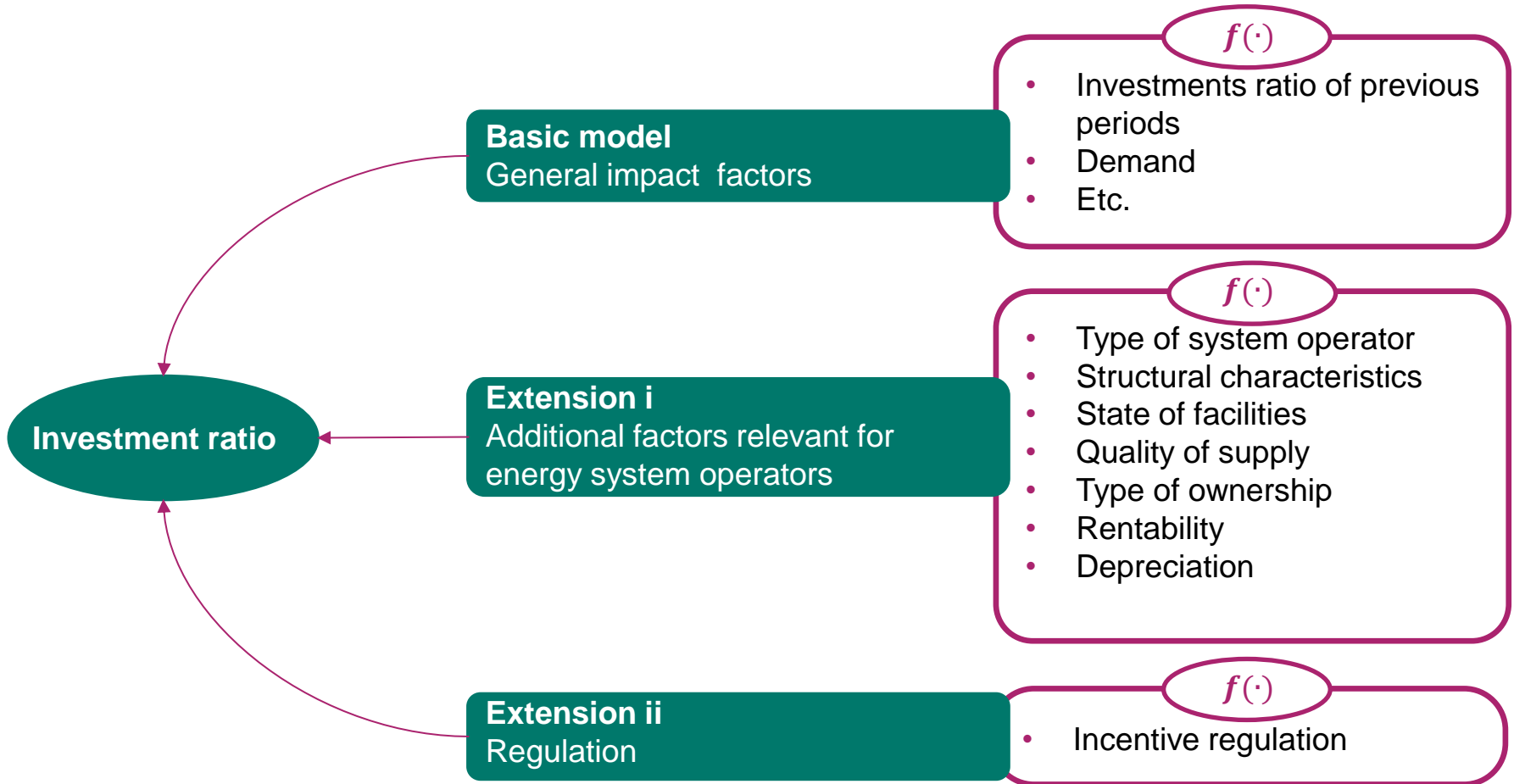
Remarks:

- 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
<b><u>Dependent variable:</u></b> Investment ratio <sub>(it)</sub> at current prices/costs		
<b><i>Basic model plus...</i></b>		
<b><i>...implementation of the incentive regulation:</i></b>		
- Implementation since 2009	+	0
- Efficiency score in RP1	++	0
<b><i>... design of the incentive regulation:</i></b>		
- 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<sub>(it)</sub> 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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