No Barriers to Investment in Electricity and Gas Distribution Grids through Incentive Regulation

By Astrid Cullmann, Nicola Dehnen, Maria Nieswand and Ferdinand Pavel

Since early 2009, electricity and gas distribution in Germany has been subject to incentive regulation designed to ensure greater efficiency in electricity and gas grid operation. However, it remains to be seen how changes to the regulatory framework will affect the investment behavior of distribution system operators. Against this background, the present study empirically analyzes the investment activities of distribution system operators for the period from 2006 to 2012. The key questions are whether the introduction of incentive regulation in 2009 has had an empirically demonstrable impact on investment and whether this effect is due to the introduction of incentive regulation per se, or to its specific design. The findings show a positive effect on investment since the introduction of incentive regulation which, in particular, is determined by the specific design of regulation.

German electricity and gas grids have been subject to incentive regulation since early 2009 (see Box 1). Changes to the regulatory regime are to encourage distribution system operators to reduce their costs to an efficient level. It is currently being discussed, however, to what extent incentive regulation affects investment decisions. Against this background, the German Federal Network Agency (*BNetzA*), as the responsible regulatory authority, has captured data on the investment behavior of German distribution system operators based on a representative sample and commissioned DIW Econ and DIW Berlin to conduct a statistical analysis of this investment behavior. The main findings are summarized and discussed here.

The key finding of the analysis is that investments were not inhibited by the introduction of incentive regulation. Rather, an increase in investment was identified when incentive regulation was introduced. However, this effect is limited to certain years and cannot be explained by factors such as the obligation to connect decentralized power generation systems. Instead, it can be demonstrated that considerably higher levels of investment occurred in the base years which were used to determine the cost of capital.[1] This suggests that the effect of incentive regulation on investment in distribution grids is determined by its specific design. These kinds of investments include replacement investments, such as substituting power cables as part of regular investment cycles, and expansion investment in the grid itself which may be required when connecting new settlement areas or decentralized power generation systems.

Effect of Incentive Regulation on Investment so far Unclear

Compared to regulation aimed primarily at the profitability of grid operation, arguments against incentive regulation posit that it can reduce incentives to invest

1 This effect can be identified in all distribution grids but is much more pronounced in electricity grids than in gas grids.

Box 1

Incentive Regulation

One key feature of a grid-based energy supply is its sub-additive cost structure which allows a single provider to operate the necessary infrastructure at a lower cost than would be possible for multiple providers together (natural monopoly). As a result, distribution system operators are basically able to make monopoly profits. Consequently, so as to prevent welfare losses, it is useful to regulate grid-based energy supply. There are basically two types of regulation for natural monopolies: rate-of-return regulation and incentive-based regulation (price-cap or revenue-cap regulation).

In Germany, the rate-of-return approach was used prior to 2009. The competent regulatory authorities, i.e., the German Federal Network Agency and the state regulatory authorities, approved grid-use charges based on actual costs and permitted return on equity. In contrast, the introduction of incentive regulation from 2009 increased incentives for distribution system operators to reduce their costs and thus increase their efficiency. In advance of the regulatory periods, individual efficiency-based revenue caps were set by the regulatory authority which could only be changed minimally during the regulatory period (five years). The incentive for distribution system operators is to take steps to increase efficiency in order to generate additional profits for themselves. The principle is that efficiency gains are passed, at least partly, to final consumers in the following regulatory period.

The revenue cap is calculated based on a cost review. The costs of the distribution system operators are determined two years prior to the start of the regulatory period. The cost basis is the last complete financial year at that point in time. This year is called the base year. The cost situation in the base year is therefore crucial for determining the revenue cap for the following regulatory period and investments made in the base year are given special consideration.

since regulated companies participate more in the investment risks.[2] Furthermore, focusing on short-term efficiency potential supersedes long-term efficiency. Short-term efficiency targets may also be achieved at the expense of replacement investments and, consequently, supply quality (such as frequency and duration of supply interruptions).[3] Similarly, the impact of incentive regulation also encourages expansion investments.

Conversely, focusing on cost reduction also compounds incentives to invest in cost-reducing technologies.[4] Incentive regulation can also be designed to specifically enhance investment incentives. For example, (replacement) investments are promoted by adjusting the revenue cap depending on supply quality. Similarly, incentives for expansion investments can be increased through investment measures that are fixed in the incentive regulation.[5]

In the context of the specific design of incentive regulations, investment barriers due to the time lag on investment returns are currently being discussed in the economic literature. It is argued that investment incentives may be weakened since some investments do not lead to corresponding adjustments of the revenue cap until the following regulatory period.[6]

Compared to the extensive theoretical literature on the effects of incentive regulation on investment incentives, there is only a small number of empirical studies on this issue. Recent international literature emphasizes that introducing incentive regulation and/or a departure from traditional rate-of-return regulation does not always lead to underinvestment in grid industries. Cambini and Rondi (2010)[7] show, for example, that the introduction of incentive regulation has had a considerable positive impact on investment for 23 of the largest energy suppliers in France, Germany, Italy, Spain, and the UK.

In summary, it can be stated that the effect of incentive regulation on investment behavior based on theoretical

2 B. Egert, "Infrastructure investment in network industries: The role of incentive regulation and regulatory independence," William Davidson Institute Working Paper (2009) no. 956.

3 See also C. Müller, C. Growitsch, and M. Wissner, "Wissenschaftliches Institut für Infrastruktur und Kommunikationsdienste GmbH (WIK), Regulierung und Investitionsanreize in der ökonomischen Theorie," IRIN Working Paper as part of the Arbeitspakt: Smart Grid-gerechte Weiterentwicklung der Anreizregulierung and P. Burns and C. Riechmann, "Regulatory instruments and investment behaviour," Utilities Policy 1 (2004): 211–219.

4 Egert, "Infrastructure investment."

5 Certain grid investments are regulated separately through investment measures in accordance with Section 23 of the Incentive Regulation Ordinance (Anreizregulierungs-Verordnung, ARegV), primarily in the area of transmission networks. They are not subject to efficiency requirements, resulting in generally higher prices because they increase revenue caps even during ongoing regulation periods. See also Müller, Growitsch, and Wissner, "Wissenschaftliches Institut."

6 G. Brunekreeft and R. Meyer, "Netzinvestitionen im Strommarkt: Anreiz- oder Hemmniswirkungen der deutschen Anreizregulierung?," Energiewirtschaftliche Tagesfragen, no. 61 (2011): 40–43.

7 C. Cambini and L. Rondi, "Incentive regulation and investment: evidence from European energy utilities," Journal of Regulatory Economics, no. 38 (2010): 1–26.

Figure 1

Investment ratio of electricity distribution system operators
Mean values in percent

Source: German Federal Network Agency; Calculations by DIW Econ and DIW Berlin.

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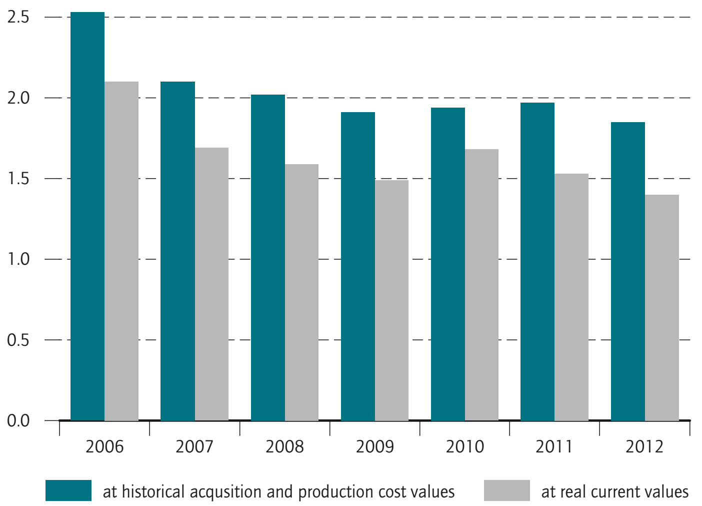
No decrease in investment ratio of electricity system operators after 2009 observable.

Figure 2

Investment ratio of gas distribution system operators
Mean values in percent



Source: German Federal Network Agency; Calculations by DIW Econ and DIW Berlin.

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No systematic decrease in investment ratio of gas distribution system operators after 2009 observable.

considerations or technical correlations is not easy to determine and is also strongly affected by its specific configuration. Rather, complex and often contradictory interrelationships require a comprehensive econometric analysis of the investment behavior of distribution system operators based on representative data.[8]

Descriptive Analysis of Investment in Electricity and Gas Distribution

The key investment figure in the present study is the investment rate of the network operators. This indicates the amount of investment relative to current tangible fixed assets as a percentage, where

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

Investments are calculated on the basis of the balance of acquisitions and disposals by investment groups and fiscal year as specified by the network operators. Acquisitions and disposals are assessed both in terms of historical acquisition cost and/or production cost, and at real current values. As a result, technical developments are taken into account that have an impact on the acquisition or replacement value of the fixed tangible asset.

The imputed investment rates of electricity distribution system operators at historical acquisition/production cost values and at real current values initially declined, and then, in 2008, reached 2.3 and 1.9 percent respectively, each rising by almost one percent by 2011, and then fluctuating at 2 and 2.5 percent respectively in 2012 (Figure 1).

The imputed investment rates of gas distribution system operators at historical acquisition/production cost values and at real current values initially declined from 2.5 and 2 percent respectively from 2006 to 2009 then rose slightly in 2010 and 2011, before falling again in 2012. Overall, the decline over the entire period is approximately 0.7 percent (Figure 2).

The development of investment rates provides an initial impression of the investment behavior of distribution system operators between 2006 and 2012. According to this first impression, investment rates have not decreased since the introduction of incentive regulation in 2009. Further, detailed statements on the underlying factors and the impact of incentive regulation can only be made on the basis of an extensive econometric analysis (multivariate regressions).

8 In particular, given the complex data requirements, this type of undertaking is only possible under the auspices of the Federal Network Agency as the competent regulatory authority.

Econometric Model Shows No Negative Effect of Incentive Regulation on Investment Behavior

The key objective of the econometric analysis is to determine whether the investment behavior of electricity and gas distribution system operators had altered significantly over time since the introduction of the incentive regulation in 2009. The investment behavior of the distribution system operators is analyzed using a suitable econometric model derived from academic literature (see Box 2).

An analysis was conducted here to determine the extent to which exogenous factors (independent variables such as the introduction of incentive regulation) impact the firm-specific investment rate (dependent variable).[9] The selection of independent variables to describe investment behavior and the heterogeneity of firms is heavily geared toward the cited literature on investment behavior (Cambini and Rondi, 2010[10]) and literature on efficiency comparisons between regulated energy supply firms (Farsi et al., 2004).[11] Since electricity and gas distribution system operators do not only differ considerably technologically but also in terms of the regulatory framework in the relevant markets, different investment models were developed for electricity and gas distribution system operators and separate estimates performed. Exogenous factors affecting our sample are shown in Tables 1 and 2. The investment rate in the previous period, gross domestic product (GDP) in the previous period, the size of the distribution system operator, the area of supply, and the number of connection points in the relevant voltage levels (medium voltage (MV) and low voltage (LV)) have emerged as the key parameters in describing investment behavior.[12] The relevant investment model is then gradually extended to analyze hypotheses pertinent to the investment behavior of distribution system operators in Germany.

Has the Investment Behavior Been Affected by the Introduction of Incentive Regulation in 2009?

The effect of the introduction of incentive regulation was tested using a dummy variable in the estimation equation which was given a value of one for the years 2009 to 2012 (dummy ARegV). As a result, the observation period was divided into two phases: i) the period before the introduction of incentive regulation and ii) the period after the introduction of incentive regulation.[13] The corresponding regression results for electricity supply firms are shown in Table 1.[14] The positive coefficient of the ARegV dummy is statistically significantly different from zero (at the ten-percent level). It may initially be assumed that the investment rate in the years after the introduction of incentive regulation is,

9 The investment rate is defined as the calculated investment rate based on investment at current new values. Investment volumes are not measured in absolute amounts in order to better separate the possible impact of exogenous factors from purely size effects.

10 Cambini and Rondi, "Incentive regulation and investment."

11 M. Farsi and M. Filippini, "Regulation and measuring cost efficiency with panel data models application to electricity distribution utilities," Review of Industrial Organization 25(1) (2004): 1–19.

12 The investment behavior of the gas distribution system operators is also considerably influenced by the geographical location of the system operators (former East or West German states).

13 Due to the dynamic structure of the investment model, however, it should be added that 2008 is the only year before the introduction of incentive regulation that can be considered in this regression.

14 The regression coefficient indicates how strong the link is between investment behavior and explanatory variable. If it is positive, then the corresponding variable has a positive effect on the investment rate. In addition, standard errors and p-values are given in order to check the statistical significance of the coefficient (*** significant at the one-percent level, ** five-percent level, and * ten-percent level).

Box 2

Methods

The starting point for the empirical analysis is a micro-econometric investment model with a dependent variable (the investment rate) and several independent variables (variables determining investment behavior in the current period, as well as control variables indicating the structural differences between electricity and gas distribution system operators). In micro-econometric literature on investment models[1] it is generally assumed that current investment behavior depends on that in the previous period. This dynamic must be taken into account in the estimation equation. The use of conventional estimation methods such as the ordinary least squares (OLS) or maximum likelihood (ML) methods may lead to an endogeneity problem and distorted estimation results. In dynamic models, therefore, investment behavior in the previous period is replaced (instrumented) by investment behavior from even earlier periods. The instrument variable estimation used in the present study to explain the investment behavior of distribution system operators is based on the principle of the generalized method of moments (GMM).[2]

1 G. R. Hubbard, "Capital market imperfections and investment," Journal of Economic Literature 36 (1998): 193–225. T. Lyon and J. Mayo, "Regulatory opportunism and investment behavior: Evidence from the U.S. electric utility industry," Rand Journal of Economics 36 (2005): 623–644.

2 R. Blundell and S. Bond, "Initial conditions and moment restrictions in dynamic panel data models," Journal of Econometrics 87(1) (1998): 115–143.

Table 1

Estimation results for electricity distribution system operators – Introduction of incentive regulation
Dependent Variable: Investment Ratio

Independent Variables	Coefficient	Standard Error	P-Value	Statistical Significance
Investment ratio of previous period	0.846	0.070	0.000	***
GDP of previous period	−5.112	1.179	0.000	***
Size of system operators	0.115	0.048	0.017	**
Area of supply at LV	0.060	0.027	0.027	**
Number of connection points at LV	−0.053	0.022	0.015	**
Geographical area at MV	−0.043	0.023	0.065	*
Number of connection points at MV	0.030	0.018	0.089	*
Constant	22.887	5.558	0.000	***
Dummy ARegV	0.104	0.062	0.091	*
Efficiency Value	0.939	0.380	0.014	**

*Note: Number of observations: 483. Number of distribution system operators: 99. Statistical significance at the *** 1-percent level, ** 5-percent level and * 10-percent level.*

Source: German Federal Network Agency; Calculations by DIW Econ and DIW Berlin.

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The investment ratio of electricity distribution system operators is significantly higher after the introduction of incentive regulation.

Table 2

Estimations results for gas distribution system operators – Introduction of incentive regulation
Dependent Variable: Investment Ratio

Independent Variables	Coefficient	Standard Error	P-Value	Statistical Significance
Investment ratio of previous period	0.844	0.156	0.000	***
GDP of previous period	−0.043	0.454	0.340	
Size of system operators	0.239	0.113	0.035	**
Former East German States	0.198	0.107	0.063	*
Area of supply	−0.069	0.267	0.010	**
Number of exit points	0.170	0.057	0.003	***
Constant	0.326	0.590	0.580	
Dummy ARegV	0.083	0.088	0.350	
Efficiency Value	−0.740	0.740	0.318	

*Note: Number of observations: 309. Number of distribution system operators: 63. Statistical significance at the *** 1-percent level, ** 5-percent level and * 10-percent level.*

Source: German Federal Network Agency; Calculations by DIW Econ and DIW Berlin.

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In case of the gas distribution system operators there is no significant influence of incentive regulation on the investment ratio.

on average, significantly higher than in the period prior to its introduction.

Also, the influence of a firm-specific efficiency value was tested. This was calculated for each distribution system operator on the basis of benchmarking methods in the first regulatory period.[15] The firm-specific efficiency value has a positive correlation with the rate of investment. From this estimated finding, it follows that electricity distribution system operators which were assessed as relatively efficient before the start of the incentive regulation have a higher average investment rate.[16]

Unlike for power distribution system operators, there is no indication of any significant influence of the ARegV dummy on gas distribution system operators (see Table 2). Apparently, their investment behavior has not been affected by the change in the regulatory regime. This finding is maintained even if the efficiency value from the first regulatory period is also taken into account. This has no significant effect on the investment rate either. Consequently, investment behavior is not significantly adversely affected by introducing incentive regulation.

Are Investment Decisions Heavily Affected by the Design of the Incentive Regulation?

It was also examined whether specific legal requirements and standards affect investment behavior in the observation period. The revenue cap and the associated initial level of costs also play a major role in the design of incentive regulation.

Costs from the base year are used to determine the initial level for the revenue cap in the relevant regulation period. Consequently, investments made in the base year are given special consideration.[17]

A dummy variable given the value one in the base year should determine whether there has been a base year effect on the investment behavior of the distribution system operators, since the investments were treated separately for the purposes of cost verification.

The estimated findings for the electricity distribution system operators shown in Table 3 suggest that the ARegV dummy loses its relevance when taking into account the base year effect. In contrast, the coefficient of the base year is positive and statistically significant.

15 See S. Seifert, "Effizienzanalysemethoden in der Regulierung deutscher Elektrizitäts- und Gasversorgungsunternehmen," DIW Roundup, no. 40 (DIW Berlin, 2014).

16 However, the impact direction of the two parameters cannot be clearly determined. On the basis of these findings, it is not possible to conclude, for example, that a lower efficiency value prevents investment and therefore moderate specifications to reduce inefficiencies are required.

17 The base year for the first regulatory period (2009–2012 for gas distribution system operators and 2009–2013 for electricity distribution system operators) was 2006, and for the second regulatory period, the base year was 2011 (for electricity distribution system operators) and 2010 (for gas distribution system operators).

This leads to the conclusion that the previously observed positive effect of introducing incentive regulation is primarily due to increased investment in the base years. Therefore, it is, in particular, the design of incentive regulation that explains the investment behavior of distribution system operators.

Overall, the base year effect identified in the regression model corresponds to the development of investment behavior described previously. In this respect, the result of the regression model is not surprising. Rather, the level of investment and the investment rates suggest that these were higher, not only relative to 2008 (as evidenced by the regression analysis), but also relative to previous years (since 2006 at least). In addition to a base year effect attributable to incentive regulation, other developments, particularly the expansion of decentralized power generation systems under the German Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz, EEG*) could have caused the increase in investment. Nevertheless, decentralized production rose continuously in the observation period, both in terms of the number of plants and installed capacity (installed capacity from 2009 actually rose by over ten percent annually). In contrast, investment and investment rates in 2012 fell to the levels they were in 2009 and earlier. Even when the changes in decentralized power generation are taken into account, as part of an in-depth econometric analysis, the existence of a base year effect is reaffirmed.

A significant base year effect is identified for gas distribution system operators when the introduction of the incentive regulation (ARegV dummy) is not taken into account. On the basis of these findings, the existence of a weak base year effect can therefore be determined for gas distribution system operators. However, it is not as pronounced as for electricity distribution system operators.

Conclusion

Electricity and gas distribution system operators in Germany have been subject to incentive regulation since 2009. It has been hotly debated how grid replacement and expansion investments have developed under the new regulatory framework. The present *Economic Bulletin* uses econometric methods for the first time to analyze investment behavior by electricity and gas distribution system operators in Germany separately. The main finding of the study is that investment behavior has not been adversely affected by the introduction of incentive regulation. For electricity distribution system operators, the analysis shows a significant positive relationship between the introduction of the incentive regulation and the investment rate of distribution system operators. Further analysis shows that this effect is due to the design of the regulation, since it uses significantly higher investments in the base year to determine capital costs. In summary, the analysis shows that investment incentives have been compounded by the introduction of incentive regulation. This is of particular relevance to the challenges arising from the energy transition, such as the further expansion of renewable energy sources.

Table 3

Estimations results for electricity distribution system operators – Design of incentive regulation

Dependent Variable: Investment Ratio

Independent Variables	Coefficient	Standard Error	P-Value	Statistical Significance
Investment ratio of previous period	0.835	0.068	0.000	***
GDP of previous period	0.018	0.024	0.453	
Size of system operators	0.096	0.048	0.045	**
Area of supply at LV	0.060	0.029	0.039	**
Number of connection points at LV	−0.054	0.023	0.019	**
Geographical area at MV	−0.025	0.021	0.231	
Number of connection points at MV	0.024	0.019	0.192	
Constant	−0.165	0.067	0.014	**
Dummy base year	0.205	0.065	0.002	***
Dummy ARegV	0.021	0.076	0.784	

*Note: Number of observations: 483. Number of distribution system operators: 99. Statistical significance at the *** 1-percent level, ** 5-percent level and * 10-percent level.*

Source: German Federal Network Agency; Calculations by DIW Econ and DIW Berlin.

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Investment decisions are significantly influenced by the design of incentive regulation.

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