Regulation and Investment Incentives in Electricity Distribution: An Empirical Assessment

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Abstract

In this paper we analyze the investment behavior of electricity distribution companies. First, we test whether the implementation of an incentive-based regulatory scheme with revenue caps impacts the firms' investment decisions. Second, we test if the specific regulatory design to determine the revenue caps impacts the firms' investment behavior. The analysis is based on a unique and detailed firm level data for German electricity distribution companies over the 2006-2012 period. Controlling for firm specific heterogeneity and ownership structure, we show that the investment rate is higher after the introduction of incentive regulation in 2009. Furthermore, we find that the specific institutional constraints for determining the revenue-caps embedded in the regulatory design, influence the investment decisions of the firms. Especially in the base year, when the rate base is determined for the following regulatory period, investments increase. The analysis demonstrates that the whole design of incentive regulation must be taken into account for a sound assessment of investment behavior in electricity distribution.

1 Introduction

Electricity distribution companies are regulated natural monopolies. Therefore, investment decisions are not purely driven by market mechanisms. Rather, they are strongly influenced by regulatory framework and institutional constraints (Vogelsang, 2002). The importance of investments in electricity distribution stems from the fact that they are not only crucial for prices and quantities in the long run (Guthrie, 2006), they also require vast sums of money and are usually irreversible (Vogelsang, 2010). Given the increased decentralized generation as well as the massive expansion of renewable energies and their feeding-in, investments in this sector are of core interest to recent energy policy and regulation. Clearly, in order to manage the energy transition towards a carbon free electricity generation, large investments are necessary in both the short and long run in order to maintain, expand, and modernize the network infrastructure.[1]

Against this background, much attention is devoted to the question of whether incentive regulation, which has been introduced in the electricity sectors across Europe, provides sufficiently enough incentives to foster investments in the energy networks. The main goal of this paper is to shed light on this

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[1]For Germany the expected volume of investments amounts up to 27.5 Billion Euro until 2030 (dena, 2012).

question by analyzing the investment behavior of electricity distribution companies in Germany, where an incentive-based regulatory regime with revenue caps was introduced in 2009.

Since the 1990s regulation in all European countries have undergone substantial changes: in order to improve firms' incentives to increase efficiency and to reduce costs, many countries changed their regulatory approach from rate-of-return (with cost-plus) regulation, where the companies recovered their costs with a risk-free fixed rate-of-return, toward various forms of incentive regulation schemes.[2] The interdependency of regulatory schemes and investment incentives is a major subject of debate in the theoretical literature. Within this literature, there exists consensus that the respective regulatory scheme and the investment behavior of regulated companies are closely related to each other (Guthrie, 2006). However, keeping all specific legal and institutional constraints in mind, the relationship is not trivial, theoretical predictions are not always clear-cut, and conclusions are ambiguous (Bottasso and Conti, 2009). The theoretical literature shows that in network industries either kind of regulation, rate-of-return and incentive based regulation, can yield (over-) underinvestment depending on the specific design of the regulatory system (Egert, 2009). To evaluate the functioning of different systems, robust empirical support for explanation of the investment behavior of firms is needed as existing literature is very limited.[3]

The empirical literature concentrates on very general cross-country studies that look at different regulated sectors at the same time. For instance, Cambini and Rondi (2010) investigate the relationship between investment and regulatory regimes (incentive versus rate-of-return regulation) for a sample of EU energy utilities operating in the electricity and gas transmission and distribution from 1997 to 2007. They show that the investment rate is higher under incentive regulation compared to rate-of-return regulation. Egert (2009) analyzes the effect of the overall regulatory framework on sectoral investments in network industries (energy, water, rail, telecommunication) using data from different OECD countries. The author finds that network investments are positively influenced by the joint implementation of incentive and independent sector regulations. Furthermore, Alesina et al. (2005) investigate the effects of regulation on investment in the transport (airlines, road freight, and railways), communication (telecommunications and postal) and utilities (electricity and gas) sectors in the OECD and find that regulation is negatively related to investment, which is an important engine of growth. However, the relevant empirical literature focuses on large national companies and adopt a very general cross-country approach, which neglects the legal and institutional regulatory characteristics at the country level. They are not very specific on the network structure and do not model observable firm-specific heterogeneity in the production process of the firms. In 2014, Poudineh and Jamasb (2014) provide an empirical analysis for Norway. The authors analyze the determinants of investments for 129 Norwegian electricity distributing companies observed from 2004 to 2010, finding that investments are mainly driven by the investment rate in previous year, socio-economic costs of energy not supplied, and the useful life of assets. However, the analysis does not involve a change of the regulatory scheme.

This paper makes a contribution to the literature on the topic in the following ways: First, we consider one specific country, Germany, where the regulatory scheme changed from rate-of-return regulation to

[2] Across European countries price or revenue cap regulation is extensively used in electricity distribution. Within this framework the price or revenue caps are set based on the general formula $RPI - X$, thus the maximum rate of price (revenue) increase equals the inflation rate of the retail price index (RPI) less the expected efficiency savings (X).

[3] The empirical literature considering the link between regulation and investment incentives mainly focuses on investments in the U.S. American telecommunication sector. For example, Greenstein et al. (1995) underline that incentive regulation helped to promote deployment of new technologies in the U.S. telecommunications sectors in the late 1980s and early 1990s.

incentive regulation. Thereby, we analyze the impact of i) this transition in general, and ii) of specific institutional and regulatory constraints on the investment behavior of electricity distributing companies. Second, we argue that investment decisions are also highly influenced by firm-specific factors related, e.g., to the characteristics of the network or the specificities of the distribution area.[4] Controlling for observed and unobserved heterogeneity is, therefore, important when explaining differences in the investment behavior of the firms. Third, the empirical analysis is based on a representative sample, also including the small distribution companies in order to show a complete picture of the investment behavior with respect to the implementation of incentive regulation. We especially controll for the size of the companies in our estimations, according to a size criteria in the German Incentive regulation law, to look at heterogeneous effects of big versus small firms. We find robust evidence that smaller firms show a different investment behavior than smaller ones.

We derive a microeconometric investment model based on Hubbard (1998) and Lyon and Mayo (2005) controlling at the same time for firm specific heterogeneity in terms of differences in the production technology and the size of the companies. As most of the distribution companies are still controlled by local governments, we further control for the ownership structure to ensure robust empirical support for explanation of the investment behavior of regulated companies (Martimort, 2006).[5] We apply two different instrumental variable (IV) estimation procedures based on the general method of moments (GMM) to estimate the investment model: The IV GMM framework according to Hansen (1982) and the system GMM following Blundell and Bond (1998).

The analysis is based on very rich firm level data collected by the German Federal Network Regulator (Bundesnetzagentur). In this respect the data base is unique as it relates detailed firm specific data, with financial and regulatory data that is not used in the previous literature. The results of our work indicate that the implementation of incentive regulation via revenue caps had a positive effect on companies' investment. We find empirical evidence that the specific design to determine the revenue caps plays an important role in the firms' investment decisions: investments especially increased in the base-year, the year which serves as cost basis for the calculation of revenue caps. Thus, our empirical results yield important insights on the regulation of network companies and have implications for the design of regulatory policy.

The remainder of this paper is organized as follows. In Section 2 we review the related theoretical literature and derive the two underlying hypotheses of the paper. In Section 4 we derive the empirical model and our estimation strategy. Section 3 shows our data and summary statistics whereas in Section 5 we discuss our empirical findings. Section 6 concludes.

[4]The benchmarking literature on electricity distribution companies emphasizes the importance of controlling for observed as well as unobserved firm specific heterogeneity to describe the underlying production process (Farsi and Filippini, 2004; Farsi et al., 2006).

[5]Bortolotti and Faccio (2009) point out that ownership matters for the relationship between regulators and regulated firms incentives to invest and for their financial decisions. Bortolotti et al. (2011) study especially the effect of ownership and regulatory independence on the interaction between capital structure and regulated prices.

2 Related literature and derived hypotheses

We review in the following the theoretical literature on the relation between the regulatory framework and investment incentives. We hereby focus on electricity distribution[6] and on the two basic regulatory regimes: the rate-of-return regulation and the incentive regulation. We then focus on the importance to consider the specific design of the regulatory scheme with respect to legal and institutional constraints. From the existing theoretical models we derive our empirical testable hypotheses.

2.1 Rate-of-return versus incentive regulation and investment incentives

2.1.1 Rate-of-return regulation

Prior to the use of incentive regulation rate-of-return regulation has been used over a long period for the regulation of network operators. Traditionally, rate-of-return regulation, where a ceiling is imposed on the rate-of-return on capital, is considered to lead to overinvestment. In case that the rate-of-return exceeds the cost of capital firms substitute capital for labor to increase profit which leads to a high capital labor ratio and therefore allocative inefficiency (Averch and Johnson, 1962). The literature intensively debates the well known Averch-Johnson effect; however more recent literature also shows that under certain circumstances (such as the timing of the regulatory cycle, or the level of uncertainty) under-investment can occur (Egert, 2009).

2.1.2 Incentive regulation and cost reducing investment

The traditional literature on incentive regulation shows that price caps are superior to rate-of-return regulation as far as the promotion of *cost reducing investment* is concerned (Cabral and Riordan, 1989). Clemenz (1991) shows that price cap regulation also provides stronger incentives for cost reducing R&D investments than does rate-of-return regulation. This result also holds in the long run, when R&D in cost reducing innovations is viewed as an ongoing process. However, models using real option theory (Nagel and Rammerstorfer, 2008; Roques and Savva, 2006) find that a too binding price cap together with an uncertain demand induces firms to cut their investments in cost reduction. An important aspect in the literature is the question whether cost reductions are only achieved at expense of service quality (Rovizzi and Thompson, 1995; Markou and Waddams Price, 1999).[7] From the existing theoretical models we conclude that incentive regulation increases the incentives for cost reducing investments with a not too binding price cap and certain demand.

However, the literature also underlines that regulation can have different impacts on the different types of investments (Guthrie, 2006; Dalen, 1998) such as, other than cost reducing investments, R&D investment, investment to maintain the status quo or to improve service quality, investments to expand the network, etc.. The literature on the relation of incentive regulation and total investments is not at all conclusive what is summarized in the following section.

[6]Another important stream in the literature considers especially investment incentives in electricity generation. Grimm and Zoettl (2013) e.g. explicitly focus on investment decisions in generating capacity for electricity spot market design.

[7]Incentive regulation, therefore, must account for service quality in the way that the regulated price is adjusted by some measure of quality to prevent firms from achieving extra profits by reducing service quality.

2.1.3 Incentive regulation and total investment

The incentive-based regulatory regimes give rise to new challenges regarding the *total level of investment* and not only the cost reducing investments. Many authors suspect that price (revenue) cap regulation would prevent firms from investing in network expansion (Poudineh and Jamasb, 2013). One major issue discussed in the literature are total investment barriers due to delay of investment returns (Brunekreeft and Meyer, 2011). The authors show that total investment incentives are weakened when additional capital costs from investments lead to a corresponding adjustments in the revenue cap only with a time delay (for example in the next regulatory period).

It is further argued that in contrast to the rate-of-return regulation, the total investment incentives under incentive regulation may be reduced, since the regulated companies are involved more in the risks of the investment in terms of future cash flows and demand changes etc. (Egert, 2009; Armstrong and Sappington, 2006). The uncertainty regarding the predictability and reliability of regulatory authorities and their regulatory decisions might lead to a too low level of investment (Egert, 2009). Based on modeling tools of real option analysis, Dixit and Pindyck (1994) show that under uncertainty delaying investments may be beneficial even though a project may indeed recover its capital costs. Dobbs (2004) underlines that under price cap regulation under uncertainty regulated firms wait longer before they invest in comparison to an equivalent competitive industry.

In contrast, Egert (2009) concludes that coherent regulatory policies can boost investment in network industries showing that incentive regulation implemented together with an independent sector regulator (indicating lower regulatory uncertainty) has a strong positive impact on investment in network industries.

Guthrie et al. (2006) show the effect of different asset valuation methods to determine the regulatory asset base on the investment behavior. In this context, cost disallowances (costs that are not accepted by the regulator to include in the rate base) may lead firms to cut back or reschedule investment plans (Guthrie, 2006).

Similarly, the application of the so-called benchmarking methods[8] to determine the efficiency value and thus the cost savings in the revenue cap might have an impact on the strategic investment behavior of the network operators. Poudineh and Jamasb (2013) show for electricity distribution companies in Norway that investment decisions depend on the reached efficiency level of the previous and the expected efficiency value in the following period.

The theoretical contributions and predictions on the link between the incentive regulation and total investments are not conclusive. Cost reducing incentives increases under incentive regulation in comparison to rate of return regulation. However, uncertainty and specific institutional constraints under incentive regulation might decrease the investment incentives. Thus, robust empirical support is needed on the relation of the incentive regulation and total investments. We test if uncertainty and specific institutional constraints dominate in the investment decisions of the firms resulting in a negative impact of incentive regulation on total investments.

Hypothesis 1: Implementation of incentive regulation has a negative impact on total investment

Section 2.1.2 and 2.1.3 show that on the one hand investment incentives in cost reducing investment in-

[8] For an overview of benchmarking methods within incentive regulation see e.g. Farsi and Filippini (2004) and Farsi et al. (2006).

creases whereas investment incentives decrease due to a higher risk carried by the companies in comparison to rate-of-return regulation (Cabral and Riordan, 1989; Armstrong and Sappington, 2006). Therefore, we test empirically if the implementation of incentive regulation with revenue caps in 2009 in Germany has a negative significant impact on firms total investments decisions.

2.2 Timing of investment decisions

In addition to the general impact of the introduction of incentive regulation, the theoretical literature especially stresses the influence of specific institutional and legal requirements on investment incentives of the regulated companies (Guthrie, 2006). The literature especially focuses on the fact that price (or revenue caps) are based themselves on firms' investment or cost decisions and their timing, and therefore, are not strictly exogenous to the firms.

The literature affirms that the timing of regulatory decisions and their implementation as well as the length of regulatory periods are especially relevant factors for investment decisions. Regulated companies tend to invest directly after the regulatory review to maximize payoff (Sweeney, 1981) as they will enjoy excess profits until the regulators lower prices to a level consistent with the new conditions. The longer the delay before regulatory response (and thus the higher the certainty about future prices), the greater are the incentives to invest and derive profits from cost reduction. Biglaiser and Riordan (2000) also analyze the dynamics of regulation and show that under price caps, investment in cost reduction is more likely to occur in the early years of a regulatory cycle. They show that, in comparison to a rate-of-return regulation, the incentives for replacement investments increase under a dynamic price cap regulation as long as newer equipment leads to technical progress (Biglaiser and Riordan, 2000).

Pint (1992) shows that under price-cap regulation, where regulatory hearings occur at fixed intervals and the timing of hearings is known to the firm in advance, the companies plan their capital choices over the whole regulatory cycle. Assuming that the companies maximize the discounted sum of future profits, the analysis indicates that higher investment occurs particularly in periods when costs are being measured for regulatory purposes.[9]

Hypothesis 2: Firms increase their investments in the base year

The second hypothesis is related to one important specific institutional constraint (or design) of the regulatory scheme, the determination of the regulatory rate base. Pint (1992) shows that investments are higher particularly in periods when costs are being measured for regulatory purposes. Biglaiser and Riordan (2000) show that under price caps, investment in cost reduction is more likely to occur in the early years of a regulatory cycle. Figure 1 shows the different steps and the regulatory cycles within German incentive regulation. Revenue caps are assigned to the firms at fixed intervals and are calculated based on a cost review. The regulatory cost basis of the distribution system operators is 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 which 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. We test whether firms behave strategically and tend to invest more in the base year to increase the rate base.

[9] Pint (1992) also underlines the use of average costs to determine the rate base rather than costs from a specific year (base-year costs) can have important effects on investment decisions.

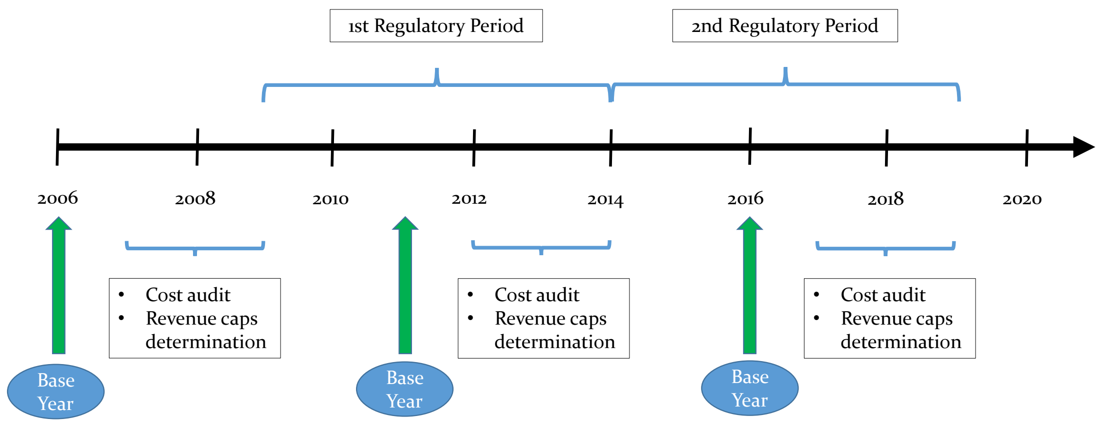

Figure 1: Time bar - Regulatory cycles and base year in German incentive regulation

3 Data

The analysis is based on a unique, representative, random panel of German electricity distribution network operators that includes yearly information on financial, technical and regulatory firm level data. The data was collected and validated by the German Regulator, the German Federal Network Agency (Bundesnetzagentur). The sample includes 109 companies and covers a six-year observation period from 2006 to 2012.[10] In general, data includes information on the balance sheets, earning reports, and tangible fixed assets (from 1960 to 2012). Detailed information concerning the customer structure, characteristics of the network and service area are also included. Further, regulatory variables such as the efficiency score, quality indicators and the ownership structure is reported. Data on the regional GDP (NUTS 2 level) has been collected and merged on company level to the data. Summary statistics for investment data, the general factors and for the environmental factors are given in Table 3 and Table 4 in the Appendix.[11]

We can differentiate between different groups of data in our empirical model to explain investment behavior: the regulatory variables (see section 3.2), firm specific characteristics and ownership structure (see section 3.3), as well as general variables driving firm level total investments (see section 3.4).

3.1 Investment ratio

The key investment figure in the present study is the investment ratio of the network operators i observed in each year t. It indicates the amount of total investment relative to current tangible fixed assets as a percentage, where

$$Investment\ ratio_{it} = \frac{Total\ investments_{it}}{Fixed\ tangible\ assets_{it}} * 100 \tag{1}$$

$Total\ investments_{it}$ 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

[10]The randomly drawn companies represent a valid approximation of the whole population of the approximately 800 network operators in Germany. The data collection is described in detail and published online at http://www.bundesnetzagentur.de (Bundesnetzagentur, 2013)

[11]As the data base is not public, we are not allowed to show the maximum and minimum in the descriptives

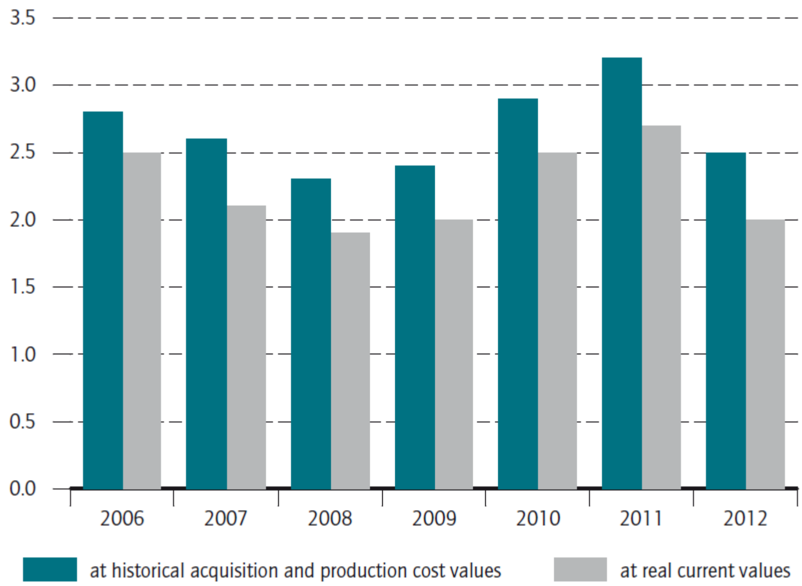

Figure 2: Investment ratio 2006 - 2012

in terms of historical acquisition cost and/or production cost, and at real current values. As a result, technical developments that have an impact on the acquisition or replacement value of the fixed tangible assets are taken into account. Figure 2 shows the average $investment\ ratios_{it}$ from 2006 to 2012, both at historical acquisition/production cost values and at real current values. Both ratios 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 (see Figure 2). For the empirical analysis we only focus on investment rates based on tangible fixed assets at current values of acquisition and manufacturing costs.[12]

3.2 Regulatory Variables

Our sample covers a period (2006-2012) when the regulatory regime switched to incentive regulation with revenue caps. To test the impact of the implementation of incentive regulation in 2009, we define a dummy $Incen\_Reg$ that takes the value of one from 2009 onwards.

$$Incen\_Reg_t = \begin{cases} 1 & \text{if year } t \geq 2009 \\ 0 & \text{if year } t < 2009 \end{cases} \tag{2}$$

[12]We do not model the investments based on commercial law calculations, since they are characterized to a considerable extent by accounting differences. The regression results would not be meaningful in this case because a clean separation between accounting differences and the possible causal relationship of variables is not possible. Furthermore, investment definitions at historical values of tangible fixed assets are not used as we analyze investment behavior over several years. As costs of service and maintenance are reported in the available sample in terms of commercial law and not on a calculatory basis (such as the investment data used), we could not consider investments plus costs for service and maintenance.

Since, after 2009, all electricity distribution companies in Germany are subject to incentive regulation, we have no control group (companies which are not under incentive regulation) and we are only able to observe and explain firms' investment behavior over time (before and after the implementation).[13] In order to reflect the whole regulatory design we test the impact of implementation together with the firm specific efficiency value Eff_Value_i the companies obtained in the first regulatory period. The Eff_Value_i is defined as

$$Eff\_Value_i = 1 - X_i \tag{3}$$

where X_i represents the firm specific cost reduction obligations determined by the regulator. The efficiency value for the first regulatory period was assigned to the companies in 2009 and determined in the previous year (2008) with cost data from 2006. For that reason we argue that the efficiency value/score is exogenous. A higher Eff_Value_i means a higher firm specific efficiency with less cost reduction obligation X_i. The efficiency score is firm specific and constant for the whole observation period. Eff_Value_i is included in the model from 2006 onwards to control for efficiency differences between the network operators.[14]

According to Pint (1992) and Biglaiser and Riordan (2000) we disaggregate the implementation of incentive regulation from the effect of the base year to figure out if firms behave strategically and tend to invest more in the base year to increase the rate base. In the investment model we therefore include a year dummy ($Base\_Year$) to figure out significant differences in the base year.[15]

$$Base\_Year_t = \begin{cases} 1 & \text{if year } t = 2011 \\ 0 & \text{if year } t \neq 2011 \end{cases} \tag{4}$$

We are aware that the base year effect is not distinguishable from a general shock in the same year and therefore the year dummies give only limited information on whether individual legal regulations or standards are responsible for a different investment behavior. Against this background it is questionable if the expansion of decentralized generation under the Renewable Energy Law (Energiewirtschaftsgesetz, EEG) could have been the driving force for investment decisions in specific years. In different specifications we therefore control for the base year effect and decentralized generation $Decen\_Gen_{it}$. $Decen\_Gen_{it}$ is defined as the annual firm specific decentralized generation capacity in high voltage lines.[16]

3.3 Firm specific characteristics and ownership structure

We argue that investment decisions are also highly influenced by firms specific factors related to network characteristics or specificities of the distribution area (Jamasb and Pollitt, 2001, 2003; Cullmann, 2012; Cullmann et al., 2006). We control first of all for the size of the companies ($Size$) by different definitions

[13] At this point we do not claim to figure out a causal effect of incentive regulation on investment behavior. This is left for further research

[14] The companies obtained their efficiency score for the next regulatory period in 2014. If we include an efficiency score only from 2009 onwards it would result in collinearity problems with the dummy $Incent\_Reg$ and the effects could not be clearly separated. To determine any causal relationship between the obtained efficiency value and investment decisions, accounting for the dynamic structure with expectations about the efficiency value in the following period more research is needed (Poudineh and Jamasb, 2013). This lies outside the scope of this paper and is left for further research.

[15] In our observation period we are only able to test the base year effect for the second regulatory period (as we use the GMM estimation procedure with the second lag as instrument).

[16] Not all network operator in our sample feed in decentralized generation in their high voltage lines. Therefore including as a control variable $Decen\_Gen_{it}$ reduces our sample from 99 observations to 58 observations per year.

of size assuming that larger firms invest differently than smaller ones. $Size$ reflects the distinction between large and small operators and is defined as a dummy variable that takes the value of one if the distribution network operator was characterized in the first regulatory period as small. Otherwise, the dummy variable is zero and the system operator is considered large. The definition is based on the threshold defined in the German Incentive Regulation Law (Section 24 ARegV). It determines for the German electricity distributors that network operators with fewer than 30,000 customers connected directly or indirectly to their distribution system can choose to take part in a simplified procedure. These companies obtain, *a priori*, an efficiency score of 87.5 percent in the first regulatory period and 96.14 in the second regulatory period. The 64 companies in our sample that take part in the simplified procedure are, therefore, characterized as small.

$$Size = \begin{cases} 1 & \text{if company takes part in simplified procedure according to Section 24 ARegV} \\ 0 & \text{if company does not take part in simplified procedure} \end{cases} \tag{5}$$

To capture firm specific network differences we control for the number of connection points CP_{it} and the service area size AR_{it}. Connections points in the electricity distribution network is the point where the electricity is physically removed by a consumer. Connection points are defined for the different voltage levels. We account for the number of connection points for low (CP_LV_{it}) and medium voltage (CP_MV_{it}). Since distribution network operators are predominantly involved in the medium and low voltage, the analysis focuses on these two parameters and we do not consider high voltage connection points, otherwise we would lose a high number of observations.[17] Service area is defined as the size of the total distribution area of a network operator in square kilometers, differentiated between the voltage levels, low voltage (AR_LV_{it}) and medium voltage (AR_MV_{it}). Accounting for the number of connection points and the service area size reflects the idea that large urban, or large regional distribution companies are characterized by a different investment behavior than small rural ones.

We further account for the ownership structure. An operator is considered as public or private, if it has only private or public ownership shares. Otherwise, the ownership structure of a network operator is considered as mixed or not clearly identifiable. We define a dummy $Public$ which takes the value of one if the company is public and a dummy $Mixed$ which take the value of one if a company has a mixed ownership. Thus, the results have to be interpreted relative to a private ownership. In our sample the ownership status is constant over the years.[18] We are aware of the very complex ownership structure in theses companies. The objective of this paper is to give a first insight and control roughly for the ownership structure. Further important research is needed in this direction based on detailed information on the public and private shares in the companies.

$$Public_i = \begin{cases} 1 & \text{if company in publicly owned} \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

[17] As a robustness check, in one model specification we also account for differences when a network operator is also active in the high voltage level. Two variables are tested: A dummy variable accounting for whether a network operator also operates cable and overhead lines in high voltage or not, as well a second variable measuring the share of high voltage cables and overhead lines in the overall network of a firm.

[18] Private ones in the sample = 25; public ones = 48; mixed ownership or unclear = 36

$$Mixed_i = \begin{cases} 1 & \text{if company has a mixed ownership} \\ 1 & \text{if ownership is not clearly identifiable} \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

3.4 General variables driving investment

According to the microeconometric investment literature we include general variables explaining firms' investment behavior.

We control for the cost of capital by the long-term interest rate (InR_t). The long-term interest rate is based on government bonds with a remaining term to maturity of ten years. In our observation period the capital markets have been distorted in a variety of ways by the financial crisis. Long-term government bonds are established in the public finance literature as "risk-free alternative". German bonds have fulfilled this during the financial crisis.

The gross domestic product (GDP) controls for the general economic situation and common effects over time due to business cycles.[19] The observation period (2006-2012) is characterized not only by the implementation of incentive regulation, but also by special economic conditions. In the wake of the 2009 financial crisis, GDP declined significantly. The development of the overall economic situation can be expressed on the national level, the national GDP ($GDP_{National}$) or on a more disaggregated level, the regional GDP ($GDP_{Regional}$) where each network operator is assigned a regional GDP based on the location of the grid areas in administrative districts and urban districts (NUTS 2 regions). We focus alternatively on both GDP definitions depending on the model specification. This allows a more sophisticated analysis in the interpretation of the results.

Sales ($diff\_Y_{it}$) are defined as the difference of logarithmic sales (the lagged real revenues to the current period). The change in demand from the previous to the current period accounts for any exogenous shock in demand (for example a cold winter). The consideration of the demand by sales (or revenues) corresponds to the usual approach in the literature. The empirical challenge is that revenues are regulated and therefore set by the regulator. We are aware that this variable might reflect changes in demand and/or regulated prices. In our framework the variable is the best choice to account for demand growth.[20]

4 Empirical Implementation

4.1 Estimation equation

Our econometric investment model is derived from the microeconometric literature on firms' investment behavior (Hubbard, 1998; Lyon and Mayo, 2005; Cambini and Rondi, 2010), the benchmarking literature and the theoretical models on the link between incentive regulation and total investments. We can separate our controll variables in three different groups: 1) the general variables driving investments ($diff\_Y$, GDP, InR), combined in the matrix X, the firm specific characteristics ($Size$, CP_{LV}, CP_{MV}, AR_{LV}, AR_{MV}, $Public$, $Mixed$) summarized in Z and the regulatory variables ($Incen\_Reg$, Eff_Value_i,

[19] GDP is price and seasonal deflated to the base year 2005

[20] We do not have better technical or physical indicators to measure the actual demand, such as the transported amount of power.

$Base\_Year$), summarized in R. α, β, γ are vectors of coefficients to be estimated.

$$Inv\_rate = \alpha' X + \beta' Z + \gamma' R \tag{8}$$

According to the literature we assume a loglinear relation for the investment model. To account for potential outliers in the data, all variables (apart from the dummies) are median corrected. Specifically, the following equation is estimated:

$$\begin{aligned} \log Inv\_rate_{it} = \alpha_0 + \alpha_1 \log Inv\_rate_{i,t-1} + \alpha_2 diff\_\log Y_{i,t-1} + \alpha_3 \log InR_{i,t-1} + \alpha_4 \log GDP_{i,t-1} \\ + \beta_1 \log Size_{it} + \beta_2 \log CP\_LV_{it} + \beta_3 \log CP\_MV_{it} + \beta_4 \log AR\_LV_{it} + \beta_5 \log AR\_MV_{it} \\ \gamma_1 Public_{it} + \gamma_2 Mixed_{it} + \gamma_3 Incen\_Reg + \gamma_4 \log Eff\_Value + \gamma_5 Base\_Year + u_i + \epsilon_{it} \end{aligned} \tag{9}$$

where i denotes the ith firm and t the year. $\log Inv\_rate_{it}$, our dependent variable, is the total investment rate for firm i in year t. As independent variables we inlcude the lagged dependent variable $\log Inv\_rate_{i,t-1}$, the general factors driving investment, observable firm specific factors and the regulatory variables. Our controll variables are defined in section 3.2, 3.3 and 3.4. Finally, u_i is an unobserved individual effect, which might be correlated with the endogenous regressors, and ϵ_{it} is an i.i.d. normally distributed random error. α, β, and γ denote the coefficients to be estimated.

4.2 Econometric issues and identification

There are several econometric issues that need to be adressed. The inclusion of a lagged dependent variable in the explanatory variables allows for the modeling of a partial adjustment mechanism of the capital stock and leads to a dynamic panel data model of investment behavior. The lagged dependent variable might be correlated with the error term and, therefore, violates the strict exogeneity assumption of the right hand side variables. This prevents us from applying simple fixed effects (FE) or random effects (RE) estimators.[21]

We therefore use two different instrumental variable (IV) estimators proposed in the literature to obtain consistent estimates (Baum, 2006; Baum et al., 2003). In a first step, we estimate the dynamic investment equation 9 using the simple IV GMM framework according to Hansen (1982). We allow for heteroskedasticity in u_i, thus the reported standard errors are robust to heteroskedasticity. The $t-2$ lag is used as an instrument.

In a second step we apply system GMM following Blundell and Bond (1998) to increase efficiency of estimation. As the system GMM uses more instruments than the difference GMM (Arellano and Bond, 1991), we argue that the system GMM is appropriate for our sample as we have a large number of network operators. The system GMM, which has been widely applied in the literature, use lags of levels and differences of the dependent and potentially endogenous or predetermined variables as instruments. More precisely, Blundell and Bond (1998) specify one equation per time period, where the instruments applicable to each equation differ (e.g. in later time periods, additional lagged values of the instruments are available). This involves a new instrument matrix to avoid loss of degrees of freedom.[22] Blundell

[21] The demeaning in a FE framework creates a correlation between regressors and error term (Baum et al., 2003) which lead to a bias in the estimate of the lagged dependent variable coefficient. The same problem arises in a RE framework where the lagged dependent variable cannot be independent of the composite error process.

[22] It is possible to include all available lags as instruments for endogenous variables. However, the number of instruments is quadratic in T, and therefore, often hard to manage in empirical application. Thus, the specification of particular lags is preferred.

and Bond (1998) show, with a small sample, that this estimator seems to be preferable to other IV and GMM estimators. Instruments may be specified as applying to differenced equation, the level equations or both.
We specify the instruments as applying to the differenced equation and tested the validity of the instruments by means of the Sargan Hansen test.[23] We further conduct a test for autocorrelation of the residuals. The residuals of the differenced equation should possess serial correlation, but the differenced residuals should not exhibit significant AR(2) behavior.
To overcome endogeneity problems in our regression we included the lagged GDPs ($GDP_{National_{t-1}}$) and ($GDP_{Regional_{t-1}}$) to represent the reaction of the current investment decisions on the last period's GDP. Moreover, we use the lagged difference of sales $diff\_\log Y_{i,t-1}$ and the lagged interest rate $\log InR_{i,t-1}$ to reduce potential endogeneity problems. We assume the firm specific characteristics as well as the regulatory variables exogenous, thus not correlated with error term.

5 Results

We start this section by deriving the microeconometric base model to describe the investment behavior of the firms. We then present and analyze regression results according to the underlying hypotheses.

5.1 Base Model

Column (1) of Tables 1 and 2 shows the regression results for the base model, based on a simple IV-GMM and the system GMM, respectively. According to Section 4.1 the lagged investment rate (Inv_Rate_{t-1}) and the lagged national GDP ($GDP\_National_{t-1}$) are included as regressors.[24] The lagged investment rate controls for capital stock adjustment in the past period, thus capturing the dynamics of the investment processes. As described in Section 4.2, the lagged investment rate is instrumented by previous lags in order to mitigate the endogeneity problem. The Sargan test does not reject the over-identifying restrictions at conventional levels (see Table 2). In our GMM estimation we could therefore use variables lagged by two or more periods as instruments. We restrict the maximum number of lags used as instruments to a maximum of two due to the possible problem of too many instruments in our observation period.
Network operators are strongly characterized by structural and technical differences. To capture firm specific heterogeneity we include variables that are related to the size of the companies ($Size$) according to a criteria within the German law, the size of the service area in the different voltage levels (AR_{LV}, AR_{MV}) and the technical differentiation of the operated network in terms of connection points, (CP_{LV}, CP_{MV}). The variables service area and the number of connections also control for the density of the service area. The estimation results are similar in both econometric specifications in terms of direction of the impact (positive, negative). With respect to the magnitude of the coefficients and the significance levels of the environmental control factors there are slight differences. In both econometric specifications the current investment rate significantly depends on the investment rate of the previous period, which indicates capital stock adjustment. A higher investment rate in the previous period leads to a higher rate of

[23]The Sargan Hansen test of overidentifying restrictions should be performed to test the crucial assumption if instruments are exogenous.
[24]We further tested the impact of the difference in sales ($diff\_Y$) and the long-term interest (InR). Both variables show no significant impact in various specifications. We removed them from our empirical model.

investment in the current period. The lagged national GDP accounts for the economic situation. The negative coefficient indicates that the investment rate declined in the current period. At a first glance, the strong negative effect does not seem plausible. In fact, further analysis will show that the effect reported here is connected to the temporal overlap of two independent events, the economic and financial crisis as well as the introduction of incentive regulation. This is shown below in Section 5.3, where we estimate an alternative specification with a regional GDP and a year dummy.[25]

The positive sign of $Size$ shows that smaller distribution network operators (with less than 30,000 directly or indirectly connected customers) tend to report a higher investment ratio than larger ones. Furthermore, the area supplied and the number of connections at the low voltage level (CP_{LV} and AR_{LV}) show a significant impact on the investment rate within the IV-GMM framework. While coefficient of the area supplied (AR_{LV}) is positive, it is negative for the number of connection points (CP_{LV}).[26] This underlines empirical evidence that rural network operators have on average a higher investment ratio than urban operators. In this context, we explicitly tested the impact of density defined as the number of connections divided per service area in the respective voltage levels (low and medium voltage). The empirical results are consistent with the base model. The density variable has a significant negative impact. Thus, rural network operators have on average a higher investment rate. The variables at the medium voltage level have no significant effect in this model specification.

Controlling for ownership, we want to determine if public network operators, or network operator with a mixed ownership structure invest in a different way (in terms of the magnitude of the investment rate) than private network operators. The results have to be interpreted relative to private ownership. Since both coefficients are not statistically different from zero (both IV-GMM and system GMM), there is no empirical evidence that public network operators show another investment behavior than non-public. The same result was found in Cambini and Rondi (2010). Based on the derived empirical investment model the main hypotheses will be examined in the following sections.

5.2 Estimating the impact of incentive regulation

The major objective of this study is to determine whether the implementation of the incentive regulation had an impact on the investment behavior of network operators.[27] A positive and statistically significant coefficient is shown in column (2) in both Tables 1 and 2. This already indicates that the investment rate in the years after the implementation of the incentive regulation is significantly higher compared to the previous period.

The firm-specific efficiency score is also added as a regressor to capture the impact of specific differences between individual network operators with regard to efficiency differences. The efficiency score is constant for the whole observation period. Table 1 demonstrates that the firm-specific efficiency score has a positive

[25]The year dummy variables captures a year specific effect such as the economic and financial crisis affecting the whole economy, while the regional GDP captures specific economic development in the region. Against this background, the size of the coefficient for the national GDP is not discussed in more detail at this point. The same applies to the interpretation of coefficient on the constant. It can be interpreted only in relation with the national GDP. Since the national GDP varies only over time and is not company specific the estimated coefficient can only be interpreted together with the constant. An estimate without a constant leads to a GDP coefficient of -0.171 (p-value 0.035) and nearly identical values for the coefficients (and standard error) of the rest of the base model parameters.

[26]In the system GMM we have the same impact in terms of the sign of the variables, however other significance levels.

[27]Due to the dynamic panel data structure and the necessity for instrumenting the lagged investment rate only 2008, before the introduction of incentive regulation, can be considered within the estimation.

Variable	Base Model	Hypothesis 1	Hypothesis 2	Decen. Gen
	(1)	(2)	(3)	(4)
	IV-GMM	IV-GMM	IV-GMM	IV-GMM
Inv_Rate_{t-1}	0.845 ***	0.846 ***	0.829 ***	0.587 ***
	0.071	0.07	0.069	0.171
$GDP\_National_{t-1}$	-5.228 ***	-5.112 ***	0.023	0.047
	1.165	1.179	0.024	0.041
$Size$	0.104 **	0.115 **	0.11 **	0.166 **
	0.048	0.048	0.048	0.081
AR_{LV}	0.058 **	0.06 *	0.062 **	0.129 *
	0.027	0.027	0.029	0.079
CP_{LV}	-0.055 **	-0.053 **	-0.053 **	-0.084 *
	0.022	0.022	0.022	0.045
AR_{MV}	-0.023	-0.043 **	-0.047 **	-0.089 **
	0.02	0.023	0.024	0.045
CP_{MV}	0.027	0.03 *	0.027	0.037
	0.018	0.018	0.018	0.027
$Constant$	24.366 ***	22.887 ***	-1.081 ***	-1.483 ***
	5.446	5.558	0.354	0.408
$Public$	-0.008			
	0.036			
$Mixed$	-0.025			
	0.038			
$Incen\_Reg$		0.104 *	0.023	0.023
		0.062	0.076	0.068
Eff_Score		0.939 **	1.022 ***	1.422 ***
		0.38	0.385	0.45
$Base\_Year$			0.204 ***	0.249 ***
			0.065	0.05
$Decen\_Gen$				0.38 ***
				0.041
N	99	99	99	58

Notes: N is number of observations; three significance levels are reported: the 1 percent (***), 5 percent (**) and 10 percent (*) level.

Table 1: Regression results for different hypotheses - IV GMM - Dependent variable is Inv_Rate

Variable	Base Model	Hypothesis 1	Hypothesis 2	Decen Gen.
	(1)	(2)	(3)	(4)
	System GMM	System GMM	System GMM	System GMM
Inv_Rate_{t-1}	0.496**	0.564**	0.560**	0.458
	-0.236	-0.245	-0.239	-0.315
$GDP\_National_{t-1}$	-3.136***	-3.632***	0.0216	0.0333
	-1.050	-1.107	-0.0441	-0.0421
$Size$	0.204**	0.204**	0.195**	0.212*
	-0.0897	-0.0953	-0.0932	-0.124
AR_{LV}	0.0976*	0.0949	0.0919	0.137
	-0.0565	-0.0586	-0.0585	-0.104
CP_{LV}	-0.0306	-0.0292	-0.0289	-0.0861
	-0.0486	-0.0503	-0.0499	-0.0646
AR_{MV}	-0.0788*	-0.0987**	-0.0991**	-0.0912
	-0.041	-0.0492	-0.0493	-0.0591
CP_{MV}	0.0566**	0.0599**	0.0564**	0.053
	-0.0274	-0.0287	-0.0287	-0.0338
$Constant$	14.52***	15.60***	-1.402*	-1.203*
	-4.905	-5.300	-0.827	-0.7
$Public$	-0.0207			
	-0.0675			
$Mixed$	-0.0628			
	-0.0735			
$Incen\_Reg$		0.170***	0.0766	0.00177
		-0.0619	-0.0669	-0.0694
Eff_Score		1.217	1.281	1.088
		-0.904	-0.914	-0.761
$Base\_Year$			0.198***	0.244***
			-0.0603	-0.0623
$Decen\_Gen$				0.395**
				-0.201
AR(1)	0.001	0.002	0.000	0.009
AR(2)	0.144	0.151	0.131	0.025
Sargan Test	0.116	0.233	0.208	0.193

Notes: Three significance levels are reported: the 1 percent (***), 5 percent (**) and 10 percent (*) level.

Table 2: Estimates for different hypotheses - System GMM - Dependent variable is Inv_Rate

and significant impact on the investment rate in the IV-GMM regression. It follows from the regression results that those network operators who were relatively more efficient before the implementation of the incentive regulation show on average a higher investment rate.[28] Overall it can be stated that the investment rate increased with the introduction of incentive regulation in 2009. The criticism that incentive regulation might introduce the risk of underinvestments in network infrastructure (Armstrong and Sappington, 2006) is not confirmed with our empirical model.[29]

5.3 Estimating the impact of the base year

We want to determine if there is a base year effect assuming that firms increase their investments in the year that serves as cost basis for the calculation of the revenue cap. The regression includes a base year dummy ($Base\_Year$) taking the value of one in 2011 (see Figure **??**) As the year dummy correlate strongly with the national GDP (national GDP varies by definition only over time and not between individual network operators) we replace the national GDP by $GDP\_Regional_{t-1}$.
Column (3) of Table 1 and 2 show the regression results. Accounting for the base year effect, the impact of the incentive regulation implementation is no longer significant. However, the coefficient of the base year effect ($Base\_Year$) is positive and significantly different from zero. This indicates that the observed positive effect of the introduction of incentive regulation on investment (without accounting for the base year) is driven by investment decisions in 2011. Thus, we conclude that the particularly the design of the incentive regulation with respect to the timing of defining the rate base, explains the investment behavior of network operators.
However, for the interpretation of the results it is important to note that the base year effect is a single year effect and all possible year specific events are depicted within the base year dummy. The base year effect is not distinguishable from a general shock in the same year and therefore the year dummies give only limited information on whether individual legal regulations or standards are responsible for a different investment behavior. Against this background, it is questionable if the expansion of decentralized generation under the Renbewable Energy Law (Energiewirtschaftsgesetz, EEG) could have been the driving force for investment decisions in the base year. We therefore test, as a robustness check, if the base year effect is still significant after controlling for decentralized generation. A first descriptive analysis shows that decentralized generation has increased continuously (in terms of the number of new plants as well as installed capacity) over the years and not only in the base year. Installed capacity increased by more than ten percent per year from 2009 onwards. In contrast, investments and the investment rate decrease again in 2012 (back to the level of the years of 2009 and before). This suggest that observed investment increase in 2010 and 2011 is not due to the increased decentralized generalization.
This is confirmed in a separate regression (see Column (4) of Table 1 and 2) controlling in addition to the base year effect for the firm specific annual change rate of decentralized generation in high voltage. Nevertheless, the base year effect is still significant. The investment rates for 2011 is significantly higher, even with a significant impact of annual changes in decentralized generation in high voltage. The

[28] In the system GMM there is no significant impact. We have to be very careful in interpreting the relationship between efficiency and investments. More research is needed to figure out any causal relationship (Poudineh and Jamasb, 2013)

[29] Unfortunately, we are not able to distinguish between different types of investment. We are not able to determine if the increase in investments is due only to an increase in cost reducing investments, as predicted by the literature. This is left for further research.

presence of a base year effect is confirmed.[30]

6 Conclusions

Historically, regulators were mainly concerned with the question how to increase cost efficiency through regulatory reforms. Currently, an important and pressing concern is how to ensure a sufficient level of investments not only in the high voltage transmission cables and lines but also in the distribution network.

It is the purpose of this paper to shed further light on the question how the 2009 implementation of incentive regulation for electricity distribution has affected the investment behavior of firms. Against the background of the energy transition with the massive expansion of renewables and decentralized generation this is an especially important issue that provides policy relevant insights for future network regulation.

The theoretical prediction on the link between regulation and investment is not always conclusive and, frequently conflicting, which demands empirical evidence. Our study provides robust empirical evidence that the implementation of incentive regulation has a significantly positive effect on firms total investment rates. The results indicate a strong base year effect that indicates firms behave strategically, investing heavily in the base years in order to increase the rate base for the following regulatory period. The effect is still significant after controlling for the increase in decentralized generation capacities. This results highlights the importance to account for specific aspects of the regulatory design to provide stable empirical support. In summary, our analysis shows that investment incentives have been compounded by the introduction of incentive regulation in Germany. This is of particular relevance to the challenges arising from the energy transition, such as the further expansion of renewable energy sources.

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[30] We also run a regression defining the years 2010 and 2011 as the base, given the fact that some costs from the second half of the year previous to the base year (2010) are added to the cost base. The results are the same.

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A Appendix - Summary Statistics

Year	Variable	Obs.	Mean	P25	P50	P75
2006	Total Investment	109	1.11E+07	484642.6	1162671	5221047
	Inv_rate	107	2.963	1.682	2.331	3.465
	$GDP\_National$	109	103.730	103.730	103.730	103.730
	$GDP\_Regional$	109	103010	34489.46	60292.61	88134.15
	$diff\_Y$	107	1.75E+08	5.20E+06	1.13E+07	5.68E+07
	InR	109	3.764	3.764	3.764	3.764
2007	Total Investment	109	1.07E+07	456243.5	1009718	3520478
	Inv_rate	108	3.634	1.624	2.165	3.001
	$GDP\_National$	109	107.250	107.250	107.250	107.250
	$GDP\_Regional$	109	104493	35115.96	60767.56	88630.3
	$diff\_Y$	108	1.70E+08	5090628	1.04E+07	6.64E+07
	InR	109	4.217	4.217	4.217	4.217
2008	Total Investment	109	1.02E+07	405401.8	961737.8	3009789
	Inv_rate	108	2.441	1.413	1.898	2.709
	$GDP\_National$	109	108.110	108.110	108.110	108.110
	$GDP\_Regional$	109	105479	35231.86	62002.16	90367.8
	$diff\_Y$	109	1.53E+08	5.42E+06	1.07E+07	6.16E+07
	InR	109	3.984	3.984	3.984	3.984
2009	Total Investment	109	1.14E+07	408820	913081.9	4482195
	Inv_rate	108	2.294	1.402	2.066	2.719
	$GDP\_National$	109	102.620	102.620	102.620	102.620
	$GDP\_Regional$	109	106899	35767.71	63755.69	93784.05
	$diff\_Y$	109	1.52E+08	6.30E+06	1.07E+07	6.08E+07
	InR	109	3.223	3.223	3.223	3.223
2010	Total Investment	109	1.61E+07	624136	1239230	5281863
	Inv_rate	108	3.425	1.785	2.481	3.431
	$GDP\_National$	109	106.570	106.570	106.570	106.570
	$GDP\_Regional$	109	107734	35914.04	63470.75	91213.84
	$diff\_Y$	109	1.64E+08	6.54E+06	1.11E+07	5.33E+07
	InR	109	2.743	2.743	2.743	2.743
2011	Total Investment	109	1.43E+07	672707.4	1382268	5383196
	Inv_rate	109	3.285	1.922	2.809	3.541
	$GDP\_National$	109	110.200	110.200	110.200	110.200
	$GDP\_Regional$	109	108234	36075.32	63641.11	89983
	$diff\_Y$	109	1.68E+08	6.66E+06	1.12E+07	5.04E+07
	InR	109	2.608	2.608	2.608	2.608
2012	Total Investment	109	1.13E+07	548474.7	1179116	3567044
	Inv_rate	109	2.489	1.455	2.083	2.835
	$GDP\_National$	109	111.180	111.180	111.180	111.180
	$GDP\_Regional$	109	110576	36699.01	64760.96	91102.91
	$diff\_Y$	109	1.79E+08	6.47E+06	1.16E+07	5.09E+07
	InR	109	1.495	1.495	1.495	1.495
Total	Total Investment	763	1.22E+07	484642.6	1141241	5046792
	Inv_rate	757	2.933	1.564	2.202	3.192
	$GDP\_National$	763	107.094	103.730	107.250	110.200
	$GDP\_Regional$	763	106632	35115.96	60767.56	90367.8
	$diff\_Y$	760	1.66E+08	6.11E+06	1.10E+07	5.84E+07
	InR	763	3.148	2.608	3.223	3.984

Table 3: Summary statistics - right hand side variables

Year	Variable	Obs.	Mean	P25	P50	P75
2006	AR_{LV}	101	208.27	10	17	64.53
	CP_{LV}	109	95541.88	4864	12492	31657
	AR_{MV}	100	2262.08	33.6	76.06	196.89
	CP_{MV}	109	3035.17	43	179	982
	Eff_Score	106	0.897	0.875	0.875	0.909
2007	AR_{LV}	101	209.42	10	17	63.7
	CP_{LV}	109	96805.49	4929	12492	34121
	AR_{MV}	100	2269.3	34.55	76.04	213.84
	CP_{MV}	109	3144.64	44	178	923
	Eff_Score	106	0.897	0.875	0.875	0.909
	$Decen\_Gen$	60	0.027	0	0	0
2008	AR_{LV}	107	203.45	9.69	17	64.53
	CP_{LV}	109	97473.98	5360	13850	35416
	AR_{MV}	106	2147.69	34.57	76.06	226
	CP_{MV}	109	3196.88	58	203	980
	Eff_Score	106	0.897	0.875	0.875	0.909
	$Decen\_Gen$	61	0.001	0	0	0
2009	AR_{LV}	109	200.39	9.69	17	64.3
	CP_{LV}	108	98508.76	5761.5	14051	38121.5
	AR_{MV}	107	2130.95	34.52	76	226
	CP_{MV}	109	3207	64	213	977
	Eff_Score	106	0.897	0.875	0.875	0.909
	$Decen\_Gen$	63	0.045	0	0	0
2010	AR_{LV}	108	203.85	9.57	17.76	64.47
	CP_{LV}	109	98024.5	6148	14343	35731
	AR_{MV}	106	2153.62	34.57	76.04	226
	CP_{MV}	109	3230.43	67	224	981
	Eff_Score	106	0.897	0.875	0.875	0.909
	$Decen\_Gen$	63	0.021	0	0	0
2011	AR_{LV}	109	204.61	10	17.55	64.64
	CP_{LV}	109	98011.78	6163	13892	36137
	AR_{MV}	108	2239.61	38.1	76.62	235.92
	CP_{MV}	109	3166.81	69	218	1033
	Eff_Score	106	0.897	0.875	0.875	0.909
	$Decen\_Gen$	64	-0.02	0	0	0
2012	AR_{LV}	109	202.88	10.1	17.55	64.64
	CP_{LV}	109	98561.28	6617	14422	36457
	AR_{MV}	108	2226.97	44.54	77.24	235.87
	CP_{MV}	109	3185.23	69	221	1056
	Eff_Score	106	0.897	0.875	0.875	0.909
	$Decen\_Gen$	63	0.015	0	0	0
Total	AR_{LV}	744	204.61	9.72	17.25	64.53
	CP_{LV}	762	97559.85	5419	13847	36016
	AR_{MV}	735	2203.37	34.7	76.08	226
	CP_{MV}	763	3166.59	60	208	983
	Eff_Score	742	0.897	0.875	0.875	0.909
	$Decen\_Gen$	374	0.015	0	0	0

Table 4: Summary statistics - right hand side variables - controll factors