The Impact of M&A on R&D of Electric Utilities based on Heckman Two-stage Model

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Abstract: Electricity industry in China and abroad is undergoing profound changes, which affect the behaviours of electric utilities in many different ways. This research empirically investigates how mergers and acquisitions (M&As) between electric utilities affect their incentives to undertake research and development (R&D) investment. The paper explores an unbalanced panel data set consisting of 125 electric utilities in the United States during 20 years sample period from 1994 to 2013. The decision to undertake R&D investment is modelled as a two-stage process. In the first stage, the electric utilities decide whether to invest in R&D at all; in the second step, the utilities will decide the amount of R&D investment. Heckman two-stage method is used for estimation. The results show that M&As have some impact on R&D investment by the electric distribution utilities.

1 INTRODUCTION

With introduction of competition in wholesale and retail electricity markets, electric utilities are taking great efforts to adapt to the new conditions and exploit new opportunities created by changes in government policies toward the industry. M&A, which plays an important role in firms' growth and competitiveness, have also been a common strategy in the electric distribution industry. During the years from 1994 to 2013, 99 deals of M&As were completed within shareholder-owned electric utilities in the United States. Innovation has received growing attention in merger reviews by competition authorities in Europe and the United States. Therefore, this paper is dedicated to examine whether the M&As between electric distribution utilities have affected their investments in R&D. Two measures of R&D inputs are of interest in this analysis: R&D expenditures and R&D intensity.

The rest of the paper is organized as follow. Section 2 is a literature review on how M&As affect R&D spending. Section 3 gives a brief theoretical analysis about the effects of M&As on R&D. Section 4 gives an introduction about M&A and R&D in the electric utility industry in the United States and summary statistics of the data used in this paper. Section 5 presents the methodology used. An empirical research is conducted based on the data in the previous section in Section 6, which is followed by conclusion and suggestion in Section 7.

2 LITERATURE REVIEW

The effects of M&As on R&D spending have been studied extensively in the R&D-intensive industries such as pharmacy and high-tech. However, only limited research has been devoted to examine such effects in the electricity industry. Of the limited empirical studies, some have focused on the effects of liberalization on R&D, and some others have analysed the drivers of R&D spending.

2.1 Literature in the R&D-intensive Industry

How M&As affect R&D spending is not conclusive in the literature. John Kwoka reviewed several retrospective merger analyses and reported that, in many cases, retrospective merger studies have found that mergers resulted in a decrease in innovation (Kwoka 2014). How horizontal mergers affect innovation of the merged entity and its non-merging competitors using data on horizontal mergers among

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pharmaceutical firms in Europe and applying propensity score matching estimators. The authors found that average patenting and R&D of the merged entity and its rivals declines substantially in post-merger periods (Haucap, et al, 2019). The impact of horizontal mergers to monopoly on firms' incentives to invest in demand-enhancing innovation is analysed. The authors find that the overall impact of a merger on innovation can be either positive or negative (Bourreau, Jullien, 2018). In contrast, (Denicolò, Polo, 2018) and (Federico, et al, 2017) analyse the effect of a merger on product innovation in a patent-race-like setting in which the scope of R&D investments has an impact on the probability of success but not on the value of the innovation. (Jullien, Lefouili, 2018) discusses the effects of horizontal mergers on innovation and shows that the overall impact of a merger on innovation may be either positive or negative.

2.2 Literature in Electric Utility Industry

(Salies 2010) studies the determinants of R&D expenditures in order to provide applied evidence of the combined effect of size and reforms on innovative activity by electric utilities. The study is based a sample of twenty European electric utilities with annual observations for the period of 1980 to 2007. The results show that firm size has a positive and significant effects on utilities' R&D expenditures. By including the M&A operation in the model, the coefficient is positive, though it is not significant. The author concluded that, by preventing consolidations of the larger firms, competition commissions may impede increases in total industry R&D efforts. (Sanyal, Cohen, 2009) investigates the R&D behaviour of regulated firms during the transition period to a competitive environment. Based on the data from US electricity market from 1990-2000, the authors analysed the effects of competition, institutional changes, and political constraints on the decline in R&D. In the selection equation, the authors included a dummy to control for pending mergers. The results show that pending mergers have a significant and negative impacts on the probability of firms' deciding to engage in R&D.

3 THEORETICAL ANALYSIS

3.1 Characteristics of R&D

The unique characteristics of R&D investment make it difficult to finance (Damanpour 2020). Firstly, R&D investments are inherently more uncertain. Innovation is a process of doing something different and exploring to the unknown world. Due to lack of the knowledge of details of new technology and unforeseeable responses from other players in the market, R&D is manifestly a process of uncertainty (Jalonen 2012). Secondly, the benefits associated with R&D investment may not be totally appropriated by the investors. Knowledge as the output of innovation activity is partially a non-excludable and non-rival good. In other words, it is difficult to keep the knowledge secret. Therefore, private firms tends to under invest in the production of knowledge since they could just be able to reap a small share of these wider benefits. Thirdly, certain R&D projects may be indivisible and require a large amount of investment to be implemented by private firms. The issue of indivisibility occurs when the project cannot be broken down into smaller, more manageable units. It means that these projects require a large amount of up-front cost, which is also known as "fixed-cost". The problem of indivisibility could be solved if capital market works perfectly. However, there are various reasons to expect that financial market is not perfect.

3.2 Effects of M&A

M&As may change firms' innovation incentives and innovation capabilities in several ways. Firstly, M&As can create large organizations (Jalonen 2012). In the absence of fully functioning markets for innovation, the aggregation of end-product market enables spreading of the costs of research over a larger sales base. New technologies such as smart grid and advanced renewable can save costs and create environmental benefits; yet producers need volume to spread the costs of these complex and expensive fixed assets. This implies that due to cost spreading, the consolidation of two or more firms can lead them to undertake R&D projects that were previously not profitable, thereby increasing the firms' incentives to innovate. Secondly, M&A may improve the firms' financial capability (Salies 2010). M&A of electric utilities can lead to significant cost savings through personnel reduction, purchasing efficiencies, administrative consolidation, reduction in corporate overhead, avoided capital expenditures, lower cost of capital, stronger credit profile and improved access to capital. Thirdly, and finally, combining knowledge bases as a result of M&A could create new knowledge and enhance firms' absorptive capabilities, which in turn increases the utilities' capabilities to innovate.

4 DATA

The data used this empirical analysis is an unbalanced panel comprised of 125 electric distribution utilities in the United States during a period of 20 years from 1994 to 2013. Data used in this paper are compiled from various sources. The data on investments in R&D are collected from FERC Form One. The investment means expenditure incurred by public utilities in pursuing research, development, and demonstration activities including experiment, design, installation, construction, or operation. It includes expenditures for the implementation or development of new and/or existing concepts until technically feasible and commercially feasible operations are verified. Figure 1 shows the total R&D, external R&D and internal R&D spending and Table 1 shows the descriptive statistics.

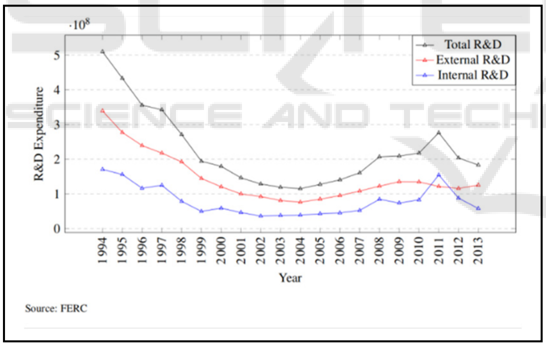

Figure 1. R&D by Investor-Owned Electric Utilities in the United States (1994-2003).

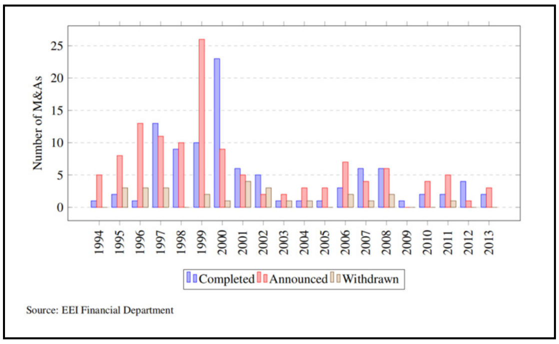

Figure 2. M&A of Investor-Owned Electric Utilities in the United States (1994-2003).

The information on mergers is taken from a compilation of Edison Electric Institute (EEI). M&A activity is defined as mergers and acquisitions of whole operating company with a regulated service territory. EEI provides a list of mergers including the information about the identity of the merging utilities, merging status (i.e. withdrawn, pending, completed), dates of merger announcement and completion, terms of deals, merger types (i.e. merger between electric utilities, merger between electric utility and independent power producers, merger between electric and gas utilities, etc.). This study focuses on the mergers between electric utilities.

Table 1: R&D data descriptive statistics.

Year	Total R&D Expenditure and Intensity[a]		
	▪ *bservations*	▪ *R &D Expenditure*	▪ *&D Intensity*
1994	2344	5588919	2.813
1995	2344	4569815	2.327
1996	2344	3685858	1.864
1997	2344	3456409	1.707
1998	2344	2592725	1.412
1999	2344	1858286	1.050
2000	2344	1660128	0.902
2001	2344	1323394	0.605
2002	2344	1168754	0.640
2003	2344	1058668	0.565
2004	2344	995829	0.540
2005	2344	1058073	0.534
2006	2344	1133133	0.598
2007	2344	1294190	0.670
2008	2344	1609265	0.818
2009	2344	1618904	0.736
2010	2344	1694890	0.793
2011	2344	2079458	1.360
2012	2344	1488672	1.000
2013	2344	1369218	0.673

5 METHODOLOGY

When modelling the impact of M&A on R&D spending, a crucial factor that should be considered is the mixed discrete-continuous dependent variable. That is, a significant proportion of the R&D spending data takes zero values and the rest are continuously distributed.

The model consists of two equations. The first equation determines whether the firm will be engaged in research activities; the second equation accounts for the expenditure or intensity of these activities (Wooldridge 2010). Suppose, in each year, a utility decides whether to invest in R&D or not. If the associated benefit from the investment is positive, the utility will make positive investment, otherwise the utility will make zero investment. The benefit of such investment is a latent variable that is not observable. But it may include the intangible benefits of complying to regulatory rules. The decision equation takes the following form:

$$d_{it} = \begin{cases} 1, \ d_{it}^* = x_{it}'\alpha + \mu_{it} > 0 \\ 0, \text{Otherwise} \end{cases} \tag{1}$$

where d_{it}^* is a latent variable, μ_{it} is the error term, x_{it} is vector of exogenous explanatory variables.

This second equation is to examine the factors that influence the level of R&D input, which is denoted by the R&D expenditure and R&D intensity. The equation takes the following form:

$$y_{it} = \begin{cases} w_{it}'\beta + v_{it}, & d_{it} = 1 \\ 0, & d_{it} = 0 \end{cases} \tag{2}$$

where v_{it} is the error term, w_{it} is vector of exogenous explanatory variables.

It is assumed that the disturbances in the two equations jointly follow normal distribution. That is,

$$\begin{pmatrix} \mu_{it} \\ v_{it} \end{pmatrix} = \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\mu^2 & \rho\sigma_\mu\sigma_v \\ \rho\sigma_\mu\sigma_v & \sigma_v^2 \end{pmatrix} \right) \tag{3}$$

6 EMPIRICAL IMPLIMENTATION

6.1 Empirical Model Specification

Stage 1: Selection Model

$$d_{it} = 1 \quad if \ d_{it}^* > 0, \text{ and } 0 \text{ otherwise} \tag{4}$$

$$\begin{aligned} d_{it}^* &= \alpha_0 + \alpha_1 Buyer_i + \alpha_2 Target_i \\ &+ \alpha_3 Merger_{it} \times Buyer_i + \alpha_4 Merger_{it} \times Target_i \\ &+ \alpha_5 MultiMerger_{it} + \alpha_6 \ln(PlantInService)_{it} \\ &+ \alpha_7 NetworkDummy_{it} + \alpha_8 RTO_{it} \\ &+ \alpha_9 \mathrm{Re}tailAccess_{it} + \sum_{t=1995}^{2013} \alpha_t Year_t + \mu_{it} \end{aligned} \tag{5}$$

Stage 2: Level Model:
Given that the utility has decided to undertake R&D investment, this stage investigates the factors that influence the magnitude of R&D spending.

$$\begin{aligned} \ln(R\&D)_{it} &= \beta_0 + \beta_1 Buyer_i + \beta_2 Target_i \\ &+ \beta_3 Merger_{it} \times Buyer_i + \beta_4 Merger_{it} \times Target_i \\ &+ \beta_5 MultiMerger_{it} + \beta_6 \ln(PlantInService)_{it} \\ &+ \beta_7 SelfGenShare_{it} + \beta_8 RetailChoiceShare_{it} \\ &+ \beta_9 IndSalesShare_{it} + \beta_{10} ROE_{it} \\ &+ \beta_{11} LongDebtRatio_{it} + \rho\hat{\lambda}_{it} + v_{it} \end{aligned} \tag{6}$$

The dependent variable is natural logarithm of positive R&D spending or R&D intensity.

In this model, i indexed the regulated electric distribution utilities, and t indexes the years. The dependent variable is the natural logarithm of R&D expenditure, which is measured in 2005 dollars, or R&D intensity. *Buyer* denotes the subset of utilities who are buyers in M&As. It takes the value of 1for the entire time period if a utility is a buyer in a merger. Similarly, *Target* denotes the subset of utilities who are targets in M&As. It takes the value of 1 for the entire period if a utility is a target in a merger. All observations on non-merging utilities constitute the control group. *Merger* is a dummy variable. If a utility involved in a merger in year *t*, the dummy will take the value of 1 in year *t* and thereafter. The inclusion of *MergerBuyer* and *MergerTarget* permits the evaluation of different effects for buyers and targets. *MultiMerger* is a dummy variable taking on a value of 1 for the years subsequent to any second merger by utilities during this period. The inclusion of inverse mills ratios (IMR, $\hat{\lambda}$) is to account for the selection effect. $\hat{\lambda}$ is calculated based on the probit equation of the first stage.

6.2 Estimation and Results

Table 2 shows the results derived from a pooled probit regression, which is added with year dummies. Column (a) compares all buyers to non-merging utilities, while Column (b) compares all targets to non-merging utilities. Column (c) shows the estimation results with all observations. I find that both state regulation and utility characteristics have important impact on the decision to undertake R&D investment. Retail access has a significant negative impact on the decision to undertake R&D investment. This variable may be picking up the effects of competition. The competition pressures may induce the electric distribution utilities to reduce costs by disengage themselves from R&D investment.

Table 2: The Decision to Undertake R&D Investment.

Variable	**Models[a,b,c]**		
	Buyer vs. Base (a)	***Target vs. Base (b)***	***B&T vs. Base (c)***
Buyer	0.636 [0.478]		0.702 [0.476]
Target		-0.104 [0.330]	-0.035 [0.308]
MergerBuyer	0.162 [0.322]		0.133 [0.346]
MergerTarget		0.363 [0.298]	0.304 [0.298]
MultiMerger	-0.666 [0.487]	-0.410 [0.392]	-0.572* [0.304]
Ln(PlantInService)	0.453*** [0.093]	0.445*** [0.092]	0.421*** [0.079]
Network Dummy	0.522 [0.341]	0.169 [0.313]	0.234 [0.252]
RTO	0.287 [0.253]	0.190 [0.244]	0.206 [0.216]
RetailAccess	-0.505* [0.289]	-0.514* [0.290]	-0.476** [0.242]
Constant	-9.184*** [1.937]	-8.931*** [1.925]	-8.429*** [1.648]
Years	Yes	Yes	Yes
Observations	1833	1705	2344
Pseudo R^2	0.249	0.215	0.224
Wald (Chi-squared)	140.255	88.525	101.006

a. Standard errors in brackets; b. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coefficients on *Buyers* is positive and that on *Target* is negative, but both are not significant in all three models. The positive sign means those utilities are more likely to undertake R&D, and the negative sign means those utilities are less likely to undertake R&D. However, both of them are not significant and show that *Buyers* and *Target* are as likely to undertake R&D as those that did not involve in M&As during the sample period.

The coefficients of the interaction terms *MergerBuyer* and *MergerTarget* are both positive in all three models. The positive sign means that M&As will increase the probabilities of buyers and targets to undertake R&D investment. However, the coefficients are not significant and I would rather to believe that M&As have no impact on the utilities' decision to invest in R&D. The coefficient on *MultiMerger* is negative in all three models and significant at 10 percent level in Column (c). The negative sign means that frequent M&As would reduce the probabilities of the utilities to invest in R&D. Since the coefficient is significant in Column (c), it shows that frequent M&As have distracted the management's attention from inner development and have negative impact on the decisions to undertake R&D investment.

Table 3: The Decision on the Level of R&D investment.

Variable	**Models[a,b,c]**		
	Buyer vs. Base (a)	***Target vs. Base (b)***	***B&T vs. Base (c)***
Buyer	-0.179 [0.300]		-0.561* [0.288]
Target		-0.805* [0.369]	-0.529 [0.323]
MergerBuyer	-0.095 [0.242]		-0.037 [0.234]
MergerTarget		-0.295 [0.282]	-0.317 [0.260]
MultiMerger	-0.363 [0.304]	0.304 [0.406]	-0.021 [0.250]
Ln(PlantInService)	0.470*** [0.122]	0.247* [0.136]	0.472*** [0.111]
SelfGenShare	0.027*** [0.004]	0.019*** [0.004]	0.024*** [0.003]
RetailChoiceShare	-0.007 [0.006]	-0.026*** [0.009]	-0.018*** [0.006]
IndSalesShare	0.018*** [0.005]	0.018*** [0.006]	0.015*** [0.005]
ROE	0.008 [0.009]	-0.003 [0.011]	0.001 [0.009]
LongDebtRatio	-0.012 [0.012]	-0.014 [0.017]	-0.018 [0.013]
IMR	-1.429*** [0.427]	-1.799*** [0.435]	-1.656*** [0.399]
Constant	3.147 2.745	9.113*** [3.132]	3.829 [2.551]
States	Yes	Yes	Yes
Observations	1341	1146	1709
Pseudo R^2	0.677	0.580	0.616

a. Standard errors in brackets; b. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3 shows the estimation results of determination on the level of R&D investment once undertaking R&D has been decided. The second stage equation is estimated using a pooled OLS model as suggest by (Wooldridge 2010). Dummies for states are included to control for the state fixed-effects. The coefficient on *ln (PlantInService)* is positive in all three models. The coefficient is positive in Column (a) and Column (c) at 1 percent level, and significant at 10 percent level in Column (b). The positive sign means that large utilities tend to invest more in R&D once the decision to undertake R&D has been made. Since the coefficient is significant in all three models, it show that utility size not only positively affect the probability to undertake

R&D but also positively affect the magnitude of R&D investment. Particularly, 1% increase in distribution plant will increase the amount of R&D investment by 0.24-0.47 percent.

The coefficient on IMR is negative and significant at 1 percent level in all three models, indicating the existence of selection. That is, some electric utilities made no investment in R&D because of their management strategies. This finding has an important policy implementation. That is, the government or regulator could come out with some appropriate policies to induce or force the utilities to undertake R&D investment. However, this does not mean that increase in R&D investment is necessary. To determine the optimal level of R&D investment of the industry requires further research.

Table 4: The decision on the level of R&D intensity.

Variable	Models[a,b,c]		
	Buyer vs. Base (a)	***Target vs. Base (b)***	***B&T vs. Base (c)***
Buyer	-0.623* [0.346]		-0.840** [0.363]
Target		-1.050* [0.570]	-0.432 [0.395]
MergerBuyer	-0.230 [0.245]		-0.259 [0.229]
MergerTarget		-0.135 [0.570]	-0.062 [0.563]
MultiMerger	-0.576 [0.535]	0.072 [0.431]	-0.180 [0.295]
Ln(PlantInService)	-0.525*** [0.124]	-0.654*** [0.139]	-0.486*** [0.106]
SelfGenShare	0.020*** [0.003]	0.020*** [0.007]	0.019*** [0.004]
RetailChoiceShare	-0.003 [0.005]	-0.010 [0.009]	-0.008 [0.005]
IndSalesShare	0.013* [0.007]	0.015** [0.006]	0.013* [0.007]
ROE	-0.015 [0.009]	-0.009 [0.011]	-0.007 [0.010]
LongDebtRatio	-0.017* [0.010]	0.004 [0.013]	-0.015* [0.008]
IMR	-1.900*** [0.474]	-1.853*** [0.557]	-1.801*** [0.465]
Constant	12.787*** [2.841]	14.753*** [3.685]	11.779*** [2.504]
States	Yes	Yes	Yes
Observations	1341	1146	1709
Pseudo R^2	0.449	0.258	0.232

a. Standard errors in brackets; b. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 shows the results of the impact of M&As on R&D intensity. The results are similar as those in Table 3. The coefficients on *Buyer* and *Target* are negative in all three models. The coefficient on *Buyer* is significant at 10 percent level in Column (a) and significant at 5 percent level in Column (c). The coefficient on *Target* is significant at 10 percent level in Column (b). The negative sign means that the R&D intensities for buyers and targets are lower than those utilities who did not involve in M&As during the sample period. Since the coefficients on *Buyer* and *Target* are significant in Column (a) and (c) and Column (b) respectively, there is some evidence that the utilities that were involved into M&As during the sample period are those with lower level of R&D intensity.

The coefficient on the interaction terms of *MergerBuyer* and *MergerTarget* are negative in all three models. However, none of them are significant. The negative sign means that involvement in M&As tends to reduce R&D intensity for both buyers and targets. Since the coefficients are insignificant, it shows that M&As have not significantly affected R&D intensity. The coefficient on *MultiMerger* is negative is Column (a) and (c), but negative in Column (b). None of them are significant at traditional confidence levels. Therefore, multiple mergers have no significant impact on R&D intensity.

7 CONCLUSIONS

The empirical analysis explores an unbalanced panel dataset consisting of 125 electric utilities during 20 years sample period from 1994 to 2013. The decision to undertake R&D investment is modelled as a two-stage process. In the first stage, the electric utilities decide whether to invest in R&D at all; in the second stage, the utilities will decide the amount of R&D investment. Heckman style two-stage method is used for estimation. Based on the analyses, it comes to the conclusions. The utilities that were involved into M&As during the sample period were as likely to undertake R&D investment as non-merging utilities. But the amount of R&D investment and R&D intensity were lower for the merging utilities than non-merging utilities. There is some evidence that multiple mergers negatively affected the utilities' probabilities to undertake R&D. But multiple-mergers had no significant impact on the amount of R&D investment and R&D intensity.

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