자원 · 환경경제연구 제 27 권 제 1 호
Environmental and Resource Economics Review
Volume 27, Number 1, March 2018 : pp. 161~194
DOI: https://doi.org/10.15266/KEREA.2018.27.1.161

Ownership Structure and Performances: An Analysis of Cooperatives and Investor-Owned Utilities in the U.S. Electric Power Industry

Heesun Jang*

ABSTRACT : This study examines performances of cooperatives relative to investor-owned firms in the US electric power industry. Using a panel data of firms from 2001 to 2014, the results show that cooperatives operate under conditions of more difficult capital constraints associated with the higher cost of debt and limited access to external equity capital. While investor-owned utilities, especially the large utilities that are less capital constrained, take benefits from substantial scale economies existing in the industry, the marginal cost of operation substantially increases with output for cooperatives. I do not find differences in profitability between the two ownership structures, measured by return on assets and return on equity. Plant capacity utilization, which is a measure of plant efficiency conditional on the operation, is also not statistically different between the two groups.
Keywords : Cooperatives, Marginal costs, Firm performances, Electric power industry

JEL 분류 : Q40, L10

Received: December 29, 2017. Revised: February 5, 2018. Accepted: February 8, 2018.

* Associate Research Fellow, Korea Energy Economics Institute, Corresponding author
(e-mail: heesun.jang@keei.re.kr)

미국 전력산업에서 기업의 소유권 형태에 따른 운영성과의 차이 분석

장희선*

요 약 : 본 연구는 미국 전력산업에서 협동조합과 민영전기사업자간의 소유권 형태의 차이가 기업의 운영성과에 미치는 영향을 분석한다. 2001년부터 2014년까지의 패널데이타를 구축하여 비용함수, 이중차분법 등을 추정한 결과, 협동조합은 높은 이자비용과 제한된 자금조달 등 소유권 형태로 인해 자본이용에 제한이 있고 운영한계비용 또한 기업 규모에 따라 가파르게 증가하는 반면, 민영전기사업자의 경우 상대적으로 자유로운 자본접근성을 바탕으로 전력산업에 존재하는 규모의 경제를 잘 활용하고 있는 것으로 분석되었다. 그러나 본 연구에서 소유권 형태가 기업의 수익성에 미치는 영향은 찾지 못하였으며, 발전효율성과 소유권형태의 상관관계 또한 통계적으로 유의미하지 않은 것으로 분석되었다.

주제어 : 전력협동조합, 한계비용, 운영성과, 미국 전력산업

접수일(2017년 12월 29일), 수정일(2018년 2월 5일), 게재확정일(2018년 2월 8일)

* 에너지경제연구원, 부연구위원, 교신저자(e-mail: heesun.jang@keei.re.kr)

I. Introduction

The purpose of this paper is to investigate the effects of ownership structure on firm performances in the context of the US electric power industry. In principal, differences in ownership structure is a consequence of different motives and incentives of firms, which would lead to different firm behaviors. For example, while it is common in the literature to assume that investor-owned firms seek to maximize their profits, as a residual return structure cooperatives are considered to have objectives other than profit maximization, although it is less clear which one. Under different objectives and organizational structures, firms should have different management practices, incentives, and control and allocation of resources, all of which would shape differences in firm performances. Such a mechanism, therefore, has the potential to explain different growth patterns across firms. Despite the intuition of this logic, the previous studies have not been fully conclusive about the effects of ownership structure on firm performances (see, e.g., Hueth and Marcoul (2015)). Part of the ambiguity is due to the limitations of data available to researchers. Ownership structure is indeed not an exogenous occurrence, but researchers do not have a source of random or even quasi-random experiment to ownership choices.

The continuing coexistence of different ownership structures indicate that each ownership has inherent advantages in pursuing their objectives. The purpose of this paper is to examine performances of cooperatives relative to investor-owned firms, and recover marginal costs of operation across firms in the electric power industry. In the US electric power industry, I observe largely four types of ownership structure: investor-owned utilities (IOUs), independent power producers (IPPs), cooperatives, and government-owned utilities. As for-profit utilities, IOUs and IPPs are likely to behave as profit-maximizing firms. IOUs are the traditional dominant electricity providers, which accounted for 89% of the total net generation in 1997. IPPs were formed under the Public Utility Regulatory Policies Act (PURPA) of 1978, which stimulated the development of non-utility power producers selling electricity acquired from cogeneration facilities and renewable energy facilities to utilities under longterm contracts (Joskow (2003)). Under the PURPA, IOUs were required to buy electricity from IPPs at their avoided costs.[1] IPPs have grown fast during the period of industry restructuring in 1990s. In 1997 only 1.6% of the total net generation was produced by IPPs, which rose to 32% in 2008. The share of the total net generation by IOUs decreased to 60% in 2008, from 89% in 1997.[2] While IOUs are vertically integrated engaging in all of the three functions of the electric power industry, i.e., generation, transmission, and distribution of electricity, IPPs are wholesale producers that produce and sell electricity only in the wholesale markets.[3]

Cooperatives have offered an alternative to IOUs in rural areas. Electric cooperatives were established since mid-1930s by federal assistance under the Rural Electrification Act to provide electricity to rural areas that IOUs were not willing to serve due to low profit margins. 9 in 10 rural farm homes were not provided electric services until the 1930s, however, more than 90% of those homes had electricity by mid-1950s. In the United States, electric cooperatives are organized as either Generation and Transmission (G&T) or distribution only. G&Ts are owned by a pool of distribution cooperatives and supply wholesale power to their member distribution cooperatives under long-term full-requirements contracts through their own generation or by purchasing power from wholesale markets. In 2014, there were 833 distribution and 65 G&T cooperatives. These cooperatives served 5% of the generation or 12% of the population covering 70% of the nation's landmass. Finally, government-owned utilities, for example, munitipal

1) Avoided cost is the cost that the IOU avoided having to acquire the same amount of electricity through other means.

2) The statistics presented in this paragraph is the author's calculation from Table ES2 in *The EIA's Electric Power Annual 2008*.

3) During the major regulatory reform aimed at introducing wholesale market competition in the late 1990s, known as "electricity restructuring", some states converted from the cost-of-service regulation to a market-based pricing in wholesale markets. However, many states resulted in abandonment of the restructuring and returned to the traditional regulation. Ultimately, 15 states implemented a market-based pricing in wholesale markets. Distribution markets have remained largely unchanged during the restructuring era.

utilities or public power districts, are non-profit state and local government agencies that provide electricity at cost. Most of these governmental utilities are small and just distribute power, but there are some large government-owned utilities that also produce and transmit electricity. In 2014, goverment-owned utilities accounted for about 15% of the generation serving 15% of the population.[4)]

As one of the highly regulated industries, virtually all firms, regardless of ownership structures, operate subject to some forms of regulations, for example, siting of power plants, renewable energy portfolios, and safety requirements. On the federal level, the Federal Energy Regulatory Commission (FERC) regulates the wholesale electricity markets, i.e., sales of electricity for resale and interstate transmission. On the state level, state public utilities commissions oversee the distribution and retail electricity markets and approve the construction of new facilities. In addition, traditionally viewed as natural monopolies, IOUs are subject to the form of cost of service regulation, where firms are guaranteed the recovery of operating expenses and a regulated rate of return on capital investments. By contrast, as wholesale providers, IPPs are not regulated under the cost of service framework but rely on the market transactions to provide revenue streams in return for their investments. Finally, cooperatives have flexibility to set rates in response to changing costs as regulatory approval is typically not required.[5)]

Although a large body of the literature investigated the electric power industry, most of the studies limited their attention to investor-owned utilities and regulation or deregulation of the industry (e.g., Fabrizio et al. (2007), Kwoka and Pollitt (2010), and Arocena et al. (2012)). There are a few studies that examined electric cooperatives, but

4) The cooperatives are organized through the National Rural Electric Cooperative Association, or NRECA. The statistics presented in this paragraph is from the NRECA's website, www.nreca.org

5) There are currently 14 states that have regulatory jurisdiction over the rates that coopera- tives can charge their members. These states are: Alaska, Arkansas, Arizona, Indiana, Kansas, Kentucky, Louisiana, Maryland, Maine, Michigan, New Mexico, Vermont, Virginia, and Wyoming. However, the degree of regulation is not consistent among the states. Moreover, the states that have jurisdiction over cooperatives often provide opt-out clauses. For example, no cooperatives remain under the jurisdiction for rate regulation in Indiana. Similarly, the states that do not regulate cooperatives provide opt-in clauses. For example, Dakota Electric excercised the opt-in option and is currently regulated by Minnesota Public Utilities Commission.

the studies yielded inconclusive results on cooperatives' performances (e.g., Atkinson and Halvorsen (1986), Claggett et al. (1995), Koh et al. (1996), and Greer (2003)). The objective of this paper is to examine the effects of ownership structure on firm performances in the context of the US electric power industry, where electric cooperatives, as an important segment of the industry, differ significantly in terms of the organizational form and the degree of regulations. In doing so, I construct a panel data of cooperatives and investor-owned utilities over 2001-2014 to examine organizational differences in performances. As typical in the literature, the data does not have a source of random assignment to ownership structure. Therefore, this paper does not study why firms choose certain types of ownership structure, but analyzes, conditional on the choice of ownership structure, what are the effects of ownership structure on performance outcomes. In the data, I see that ownership structures of electric utilities are predetermined well before the sample period, and the specifications control for observable characteristics of utilities. The observable characteristics would not be enough if cooperatives and investor-owned utilities perform in different segment of industry. In general, the two ownership structures serve different segment of the industry, as cooperatives were originated as alternatives to IOUs to serve rural areas where geographically dispersed consumers provided low returns on investment that were not served by investor-owned utilities. However, the data contains only firms that are significantly large, which mostly locate urban areas, alleviating the concern that ownership structure and firm performances may be correlated for factors that are not related with the effects of ownership structure on performances. Morover, since the data consists of firms that perform in wholesale markets, given that firms are provided the open-access to transmission systems for wholesale transactions, geographic separation is not severe to these firms.

The results show that cooperatives operate under conditions of more constrained access to capital associated with higher cost of debt and limited availability of external equity compared with investor-owned utilities. For small cooperatives, the higher cost of debt is partly offset by lower cost of equity, leading to statistically indifferent weighted average of cost of debt and equity. However, to invest in large plant is more costly for cooperatives, and the cooperatives having large plants face higher cost of debt and higher cost of capital even with viatually zero cost of equity. I find no significantly different in profitability between the two ownership structures, measured by return on assets and return on equity. Capacity utilization of power plants is also not significantly different between the two ownership structures. Finally, the estimation of the cost function shows that while the xed cost of operation is lower for cooperatives, the marginal cost of operation significantly increases with amount of electricity output for cooperatives. Finally, the results support that scale economies exists over a broad range of output in the US electric power industry, and investor-owned utilities take benets of the scale economies.

The remainder of paper is organized as follows. In Section 2, I discuss the data and present summary statistics. In Section 3, I present the empirical framework to investigate differences between cooperatives and investor-owned utilities in performance outcomes, and to estimate the marginal costs of firms across the ownership structures. Section 4 presents the results and Section 5 concludes.

II. Data and Summary Statistics

1. Data

The analysis in this paper is based on two sources of data. Specically, I use annual firm-level data for major US electric utilities collected by the Federal Energy Regulatory Commission (FERC Form 1) and annual plant-level data for existing generating plants maintained by the Energy Information Administration (EIA 860).

FERC collects financial data annually for major electric utilities in Form 1, where major means one of the following, in each of the three previous calendar years: (1) 1 million megawatt hours of total annual sales, (2) 100 megawatt hours of annual sales for resale, (3) 500 megawatt hours of annual power exchanges delivered, or (4) 500 megawatt hours of annual wheeling for others. Meanwhile, EIA 860 collects annual data on the existing electric generating plants. All the existing plants are required to le EIA 860 if the plant's nameplate capacity is 1 megawatt or greater and is connected to regional electric power grid. In Form 1, data on firm-level total assets, shareholder equity, long-term debt, interest charges, dividends declared, operating revenue and expenses, and megawatt hours of total electricity sold are available. Firms are also required to report data on power production expenses at plant-level for hydroelectric plants with a generator nameplate capacity of 10 megawatts or more, steam-electric plants with a generator nameplate capacity of 25 megawatts or more, and gas-turbine plant with a generator nameplate capacity of 10 megawatts or more. Less detailed information is reported for other plants.

Data obtained from EIA 860 includes plant technology type, nameplate capacity, and entity type that owns and operates the plant. Given the objective of this paper on the effects of ownership on firm performances, I aggregate the plant data and match with Form 1 by the firms that own the plants to use a firm-year observation. The constructed data consists of a panel of 204 firms or 2275 observations from 2001 to 2014. I consider two types of ownership structure, cooperatives and investor-owned utilities (IOU), and separate each ownership into two groups, having or not having large plants. As defined in Form 1, large plants are steam plants with installed capacity of 25 megawatt or more, or gas-turbine and hyeroelectric plants of 10 megawatt or more. In the constructed dataset, over 2001-2014 I have 32 and 6 cooperatives with and without large plants, and 96 and 94 IOUs with and without large plants, respectively. The total number of observations are 118, 67, 996, and 1094, respectively. The unbalanced nature of the panel data arises mainly due to missing observations.

Table 1 provides the list of items collected from Form 1, distinguished by the ownership structure and having or not having large plants. Total assets, shareholder equity, and long-term debt are collected from balance sheet. Interest charges, net income, and operating revenues are available in statement of income. In Table 1, after tax net income is the net income reported in Form 1 plus depreciation expense, while before tax net income is the sum of after tax net income, federal and other income taxes. Income tax information is available in statement of income. Dividends is obtained from statement of retained earnings by summing dividends declared on preferred stock and common stock.

〈Table 1〉 Items sampled from FERC Form 1

Page No.	Line No.	Description
111	85	Total assets
112	16	Total proprietary capital
113	66	Total liabilities and stockholder equity
114	2	Operating revenues
114	6	Depreciation expense
114	15	Income taxes - Federal
114	16	Income taxes - Other
114	25	Total utility operating expenses
117	70	Net interest charges
117	78	Net income
118	29	Total dividends declared - preferred stock
118	36	Total dividends declared - common stock
300	27	Total electric operating revenues
321	76	Purchased power
401a	9	Net generation (mWh)
401a	10	Purchases (mWh)

In Table 1, electric revenues is total electric operating revenues available in electric operating revenues account in Form 1. Total megawatt hours sold, megawatt hours sales to ultimate consumers and sales for resale are also available from electric operating revenues account. Electric expenses is total electric operation and maintenance expenses available in electric operation and maintenance expenses account. Purchased power

〈Table 2〉 Prime mover codes and descriptions in EIA 860

Variable	Prime mover code	Description
Steam turbine	ST	Steam turbine, including nuclear, geothermal and solar steam (does not include combined cycle)
Combustion turbine	GT	Combustion (gas) turbine (does not include the combustion turbine part of a combined cycle)
Internal combustion	IC	Internal combustion engine (diesel, piston, reciprocating)
Combined cycle	CA	Combined cycle steam part
	CT	Combined cycle combustion turbine part
	CS	Combined cycle single shaft (combustion turbine and steam turbine share a single generator)
	CC	Combined cycle total unit (use only for plants/generators that are in planning state, for which specific generator details cannot be provided)
Other	BA	Energy storage, battery
	CE	Energy storage, compressed air
	CP	Energy storage, concentrated solar power
	FW	Energy storage, flywheel
	PS	Energy storage, reversible hydraulic turbine (pumped storage)
	ES	Energy storage, other
	HA	Hydrokinetic, axial flow turbine
	HB	Hydrokinetic, wave buoy
	HK	Hydrokinetic, other
	HY	Hydroelectric turbine (includes turbines associated with delivery of water by pipeline)
	BT	Turbines used in a binary cycle (including those used for geothermal applications)
	PV	Photovoltaic
	WT	Wind turbine, onshore
	WS	Wind turbine, offshore
	FC	Fuel cell
	OT	Other

expenses is also obtained from electric operation and maintenance expenses account.

Finally, megawatt hours of electricity generated and purchased during the year are obtained from electric energy account in Form 1.

Data on nameplate capacity by technology type and ownership structure is collected from EIA 860. Table 2 shows the prime mover codes that are reported in EIA 860 for each generator. I aggregate the generator nameplate capacity by the prime mover code at the firm given year, then aggregate the prime mover codes into four technology types to calculate nameplate capacity of plants by the technology type in the firm. Finally, Table 3 shows the nine types of ownership available in EIA 860 that best describes the firms that owns and operates the plants. Industrial and commercial firms are not considered in the paper as their principal business is not electricity generation. Since there are only a few independent power producers or government-owned utilities that are reported in both Form 1 and EIA 860, cooperatives and investor-owned utilities are the only ownership structures that are considered in this paper.

〈Table 3〉 Ownership type in EIA 860

Variable	Entity type	Description
Cooperative	C	Cooperative
Investor-owned utility	I	Investor-owned utility
Independent power producer	Q	Independent power producer
Government-owned utility	M	Municipally-owned utility
	P	Political subdivision
	F	Federally-owned utility
	S	State-owned utility
Other	IND	Industrial
	COM	Commercial

2. Summary Statistics

Table 4 presents summary statistics of the variables collected from Form 1 distinguished by the ownership structure. Each ownership structure is again separated

〈Table 4〉 Descriptive statistics of rm performances by ownership

Ownership	Cooperative		IOU	
	No large plant	Large plant	No large plant	Large plant
Total Assets ($ mil)	203 (221)	789 (539)	3707 (6337)	5636 (6420)
Shareholder Equity ($ mil)	60 (68)	172 (113)	1137 (1893)	1764 (2136)
Long-Term Debt ($ mil)	112 (136)	450 (321)	1148 (1869)	1633 (1699)
Interest Charges ($ mil)	5 (7)	29 (17)	67 (122)	95 (98)
Dividends ($ mil)	0.85 (2.49)	0 (0)	69 (144)	114 (176)
Net Income (after tax, $ mil)	13 (15)	34 (22)	212 (414)	343 (433)
Net Income (before tax, $ mil)	13 (15)	34 (22)	243 (478)	378 (490)
Operating Revenues ($ mil)	121 (128)	446 (256)	1349 (2219)	2076 (2159)
Electric Revenues ($ mil)	116 (127)	446 (256)	1189 (1863)	1896 (2033)
Electric Expenses ($ mil)	97 (115)	382 (228)	790 (1224)	1282 (1361)
Total mWh sold (mWh mil)	1.6 (1.9)	7.9 (3.5)	15.6 (24.3)	53.3 (462)
Portion of Sales for Resale	0.38 (0.42)	0.99 (0.002)	0.21 (0.33)	0.29 (0.27)
Portion of Sales to Ultimate Consumers	0.61 (0.42)	0.001 (0.002)	0.78 (0.33)	0.70 (0.27)
Portion of Electricity Purchases	0.85 (0.30)	0.58 (0.30)	0.74 (0.35)	0.34 (0.24)
Portion of Electricity Generation	0.15 (0.30)	0.41 (0.30)	0.24 (0.35)	0.65 (0.24)
Number of Firms	36	6	102	94
Number of Observations	138	67	1053	1094

Notes: Standard deviations are in parentheses.

into those with and without having large plants. Table 4 shows considerable variation across the groups. Cooperatives even having large plants are a lot smaller than IOUs without large plants, measured by total assets, net income, operating and electric revenues, or total mwh sold. For example, the value of total assets of cooperatives with large plants is $789 million on average, while that of IOUs with and without large plants is $3707 and $5636 million, respectively. Most part of operating revenues is earned from electric revenues for both types of ownership, but IOUs are more diversified, in a sense that the IOUs report on average about 10% of revenues from other than electricity. Both cooperatives and investor-owned utilities report positive sales of electricity to ultimate consumers and sales for resale, suggesting vertically integrated structures.[6] Although Table 4 shows virtually all transactions are sales for resale for the large cooperatives, these cooperatives are vertically integrated with their member distribution cooperatives through long-term power purchases contracts. Both cooperatives and investor-owned

〈Table 5〉 Firm performances by ownership

Ownership	Cooperative		IOU	
	No large plant	Large plant	No large plant	Large plant
Portion of Long-Term Debt in Total Assets	0.46 (0.20)	0.57 (0.11)	0.25 (0.10)	0.29 (0.08)
Portion of Equity in Total Assets	0.35 (0.18)	0.23 (0.10)	0.36 (0.18)	0.30 (0.09)
Portion of Liabilities in Total Assets	0.64 (0.18)	0.76 (0.10)	0.63 (0.18)	0.69 (0.09)
Cost of Debt	0.03 (0.01)	0.05 (0.01)	0.02 (0.01)	0.02 (0.01)
Cost of Equity	0.007 (0.02)	0 (0)	0.06 (0.08)	0.06 (0.05)
Return on Assets (after tax)	0.06 (0.04)	0.05 (0.03)	0.06 (0.04)	0.06 (0.03)
Return on Assets (before tax)	0.06 (0.04)	0.05 (0.03)	0.07 (0.06)	0.06 (0.04)
Return on Equity (after tax)	0.45 (1.87)	0.22 (0.11)	0.18 (0.70)	0.29 (0.75)
Return on Equity (before tax)	0.45 (1.87)	0.22 (0.11)	0.22 (0.75)	0.32 (0.81)
Cost of Capital	0.02 (0.01)	0.04 (0.01)	0.03 (0.06)	0.03 (0.04)
Capacity Factor	0.27 (0.24)	0.48 (0.36)	0.31 (0.24)	0.45 (0.16)
Number of Firms	36	6	102	94
Number of Observations	138	67	1053	1094

Notes: Standard deviations are in parentheses.

6) Sales for resale means the transactions in wholesale electricity markets. Sales to ultimate consumers means the retail side of electricity, ranging from the service for a large industrial facility to small businesses and to individual households.

utilities without large plants heavily rely on purchased electricity. Specifically, cooperatives without large plants purchase 85% of the total electricity sales on average, while investor-owned utilities without large plants buy 74% of the total electricity sales from other firms. Although the portion of purchased electricity is reduced, cooperatives with large plants still purchase more than half of the total electricity in wholesale markets. On average, investor-owned utilities with large plants generate about two-thirds of the total electricity.

The variables presented in Table 4 are used to calculate performance outcomes shown in Table 5. I calculate cost of debt (COD) by dividing interest charges by total liabilities, which is equal to total assets net of shareholder equity. Cost of equity (COE) is computed by dividing dividends declared by shareholder equity. The measure of cost of capital is the weighted average of interest charges and dividends multiplied by the proportional weight of debt and equity in total assets, respectively, then taking the sum of the terms. Specifically, weighted average cost of capital (WACC) is calculated as

$$WACC = \frac{E}{A}D + \frac{L}{A}I(1-t) \tag{1}$$

where E denotes shareholder equity, A total assets, D dividends, L total liabilities, I interest charges, t tax rate. Therefore, WACC reflects a firm's cost of capital that the firm is expected to pay on average to finance its assets. To measure profitability, return on assets (ROA) is calculated as before and after taxes net income divided by total assets at the beginning of year. Similarly, return on equity (ROE) is before and after taxes net income divided by shareholder equity at the beginning of year. Finally, capacity factor is calculated as the ratio of electricity produced in plants owned by firm over year to the potential output if it were possible for the firm to operate its plants at full nameplate capacity continuously over the year. Therefore, capacity factor measures an aggregated efficiency of plants in a firm conditional on operation.[7)]

Table 5 shows that cooperatives more rely on long-term debt than IOUs, as indicated by higher portion of long-term debt in total assets. While long-term debt accounts for about half of total assets for cooperatives, investor-owned utilities finance less than one-third of their total assets from long-term debt. Interestingly, the mix of equity and liabilities is not very different for small cooperatives compared to small or large investor-owned utilities, but large cooperatives distinctively rely on liabilities than equity. This suggests that cooperatives are subject to more stringent constraints to expand firm size as they have limited access to external equity capital. Moreover, the fact that long-term debt accounts for higher portion of liabilities for cooperatives suggests that investor-owned utilities tend to borrow to fund its current operations, such as purchasing inputs, while cooperatives take on long-term debt in order to acquire capital, such as plants. This is consistent with the cost of debt significantly increasing for cooperatives, especially the ones having large plants. While IOUs on average declare about 6% of equity as dividends, cooperatives have significantly lower cost of equity, about 0.7% and 0%, for cooperatives without and with large plants, respectively. For small cooperatives, higher cost of debt is compensated with the lower cost of equity, leading to insignificantly different cost of capital. However, even zero cost of equity does not fully offset higher cost of debt for large cooperatives, yielding higher cost of capital than other groups. IOUs show higher return on assets than cooperatives before income taxes, but have about the same return on assets after income taxes. This is because cooperatives are exempt from federal income taxation as far as 85% or more of their income is collected from the members. Although return on equity seems higher in cooperatives compared with investor-owned utilities, it also shows higher standard deviations than other performance measures. Finally, capacity factor is higher for large

7) As Davis and Wolfram (2012) discussed, the capacity factor might not be an appropriate measure of efficiency if some firms excercise market power. For example, operating a portfolio of generating plants, a firm might nd it profitable to withhold capacity from some plants whose marginal costs are closer to the market clearing price.

〈Table 6〉 Plant type and capacity by ownership from EIA 860

Ownership	Cooperative		IOU	
	No large plant	Large plant	No large plant	Large plant
Steam turbine	4.30 (46.37)	104.85 (203.52)	723.63 (2378.95)	3225.10 (3442.32)
Combustion turbine	57.22 (130.09)	305.14 (383.23)	138.03 (573.54)	606.84 (841.61)
Combined cycle	43.55 (115.43)	25.24 (75.21)	83.55 (364.02)	599.21 (1509.07)
Other	5.02 (15.16)	0 (0)	188.86 (653.90)	234.70 (532.93)
Total	110.10 (256.68)	435.24 (336.35)	1134.08 (3602.57)	4665.86 (4910.04)
Number of Firms	36	6	102	94
Number of Observation	138	67	1053	1094

Notes: Standard deviations are in parentheses.

plant groups for both cooperatives and IOUs, but it does not confirm as it does not take into account that the capacity factor varies greatly across fuel and plant types. In the estimation the specications control for observable characteristics of firms including the mix of plant technologies.

Table 6 presents the controls on plant type and capacity obtained from EIA 860. Table 6 shows an interesting distinction between cooperatives and investor-owned utilities. Investor-owned utilities use steam turbine as the dominant mode of electricity generation, while for cooperatives combustion turbine is the most important mode. This reflects some systematic differences in operating decisions across the ownership structures, as the selection of plant technologies and capacity is related with the firm's decision on the scale of generation and the trade-off between construction costs and operating costs. Steam turbine uses coal or nuclear as a fuel to create steam and have a relatively low thermal efficiency, but its fuel costs is low, so steam turbine is used to meet base demand by supplying electricity nearly continuously and its relatively high construction costs are spread over continuous operation. In general, capacity of steam turbine plants is greater than that of other technologies. On the other hand, combustion turbine generates electricity by burning natural gas with higher thermal efficiency than that of steam turbine. Combustion turbine requires higher operating costs, especially fuel, which is a trade-off for lower construction costs. Typical size of combustion turbine is smaller than that of steam turbine. The fact that cooperatives have combustion turbine as the dominant mode of generation suggests that the cooperatives generate electricity during the periods of peak demand, while purchase electricity in wholesale markets during off-peak hours, when electricity prices are low. Both cooperatives and investor-owned utilities have some capacity of combined cycle plants. Investor-owned utilities also employ other types of technology, especially renewable energy plants.

III. Empirical Model

1. Differences between Cooperatives and IOUs

I first use the data to see if there are any systematic differences between cooperatives and IOUs that would lead to different performance outcomes measured from accounting information. I compare the firms along several dimensions: cost of debt (COD), cost of capital (WACC), return on assets after and before income taxes (ROA-A, ROA-B), return on equity after and before income taxes (ROE-A, ROE-B), and capacity factor (CU). Following the standard difference-in-difference specifications, the estimating equations have the form:

$$y_{it} = \alpha_0 + \alpha_1 \text{Ownership}_i + \alpha_2 \text{Large Plant}_{it} + \alpha_3 \text{Ownership}_i \cdot \text{Large Plant}_{it} + X_{it}\beta + \lambda_r + \delta_t + \epsilon_{it} \quad (2)$$

where y_{it} refers to the performance measures of firm i in year t, Ownership$_i$ is a dummy equal to 1 firm i is a cooperative and zero otherwise. Similarly, Large Plant$_{it}$ is a dummy that turns on if firm i has a large plant in year t. X_{it} is a vector of firm level controls including portion of electricity sales for resale and portion of electricity purchases in Table 4, and a set of nameplate capacity of plants owned by the firm distinguished by technology type reported in Table 6. The year fixed effects, δ_t, measures industry-level shifts over time, such as sector-level technology shocks or fuel price fiuctuations. Finally, potential spatial heterogeneity in which firms operate, such as regulatory environment, is controlled using time-invariant region effects λ_r.[8] ϵ_{it} is an unanticipated i.i.d. shocks to the performance outcomes including the measurement error. Therefore, I look at performance differences between the two ownership types by comparing firms within a region controlling for the industry-wide shocks (δ_t) and firm characteristics (X_{it}). The specification (2) allows us to interpret coefficients to those in standard difference-in-difference estimations, where the coefficient α_3 indicates the changes in performance outcomes of large cooperatives relative to those of large investor-owned utilities conditional on the decisions of ownership and large plant investments. Estimates have robust standard errors clustered at the regional level.

I note that the decisions on ownership structure and large plant investments are not exogenous. However, in the data the ownership structure of the firms was determined prior to the sample period, and given that the investments in large plants are long-term decisions, the error term in (2) is not correlated with the ownership and large plant indicators in a given year. Alternatively, the identification in (2) in part rely on the assumption that the causal effect of large plant investments create a discrete change in the performance outcomes around the event, whereas after controlling for observable characteristics of the firms, any performance trends that might lead to the selection would be common to the firms in a given regional market and a year so that partialled out in the fixed effect specications, or gradual enough to be distinguished from the discrete direct effects (Braguinsky et al., 2015).

---

8) The regions are as defined by the North American Electric Reliability Council (NERC)

2. The Estimation of Cost Function

As I will discuss in the next section, the analysis of performance outcomes in (2) suggests that cooperatives and investor-owned utilities face significantly different cost structures to finance their assets. The purpose of this section is to recover the fixed and the marginal costs of operation across the firms. By comparing the shape of the cost function across the ownership structures I can confirm the systematic differences between cooperatives and investor-owned utilities.

Consider the following model of cost minimization. To generate electricity output, denoted by Q^g, a firm needs to combine three input factors: labor (L), fuel and nonfuel materials (M), and power plants (K). The firm specific productivity (w) is known to the firm but not observed by the researcher. For firm i in year t, I specify the production function as

$$Q^g{}_{it} = Q\,(L_{it}, M_{it}, K_{it}, w_{it}) \qquad (3)$$

Let $Q \equiv Q^g + Q^p$ denote the total electricity output sold by firm, where Q^p denotes the purchased electricity. Given the production function in (3), the conditional cost function from the cost minimization is defined by

$$\begin{aligned} C_{it} &= \min_{L_{it},\, M_{it},\, Q^p_{it}} P^l_{it} L_{it} + P^m_{it} M_{it} + P^p_{it} Q^p_{it} \ \text{ subject to} \\ &\equiv C(\mathbf{P_{it}}, K_{it}, Q_{it}) \end{aligned} \qquad (4)$$

where $\mathbf{P_{it}} \equiv (P^l{}_{it}, P^m{}_{it}, P^p{}_{it})$ denotes the vector of input prices. The dependent variable C_{it} measures the total costs of electric operation and maintanence. In equation (4), firm i chooses the cost minimizing amount of generated ($Q^g{}_{it}$) and purchased ($Q^p{}_{it}$) electricity given the production technology and the total electricity demand (Q_{it}) faced by the firm. Equation (4) is a conditional cost function in the sense that it includes the power plant capacity, the total electricity output, and the productivity.

In the estimation of (4), an issue is the potential for simultaneity in the relationship between Q_{it} and C_{it}. This would arise if firms adjusted their output to accommodate the productivity shocks (w_{it}) which is also correlated with C_{it}. I accommodate the endogeneity of output (Q_{it}) by instrumenting for it with the mean of deviations of other firms' wholesale electricity prices from the regional average wholesale electricity price that are in the same region with firm *i*, denoted by $\overline{\triangle p_{-ist}}$, where -*i* and s index all other firms than firm *i* and regional wholesale market, respectively, which will be further explained below. It will be a valid instrument if, for firm *i* in region s in period *t*, the two conditions hold. First, $\overline{\triangle p_{-ist}}$ need be correlated with Q_{it}. This will be true if changes in p_{-ist}, i.e., changes in other firms wholesale electricity prices that are in the same wholesale market s, are correlated with regional electricity demand that is also correlated with Q_{it}. Second, $\overline{\triangle p_{-ist}}$ need be uncorrelated with the error term in the cost function of firm *i* in year *t*. To investigate this, let us model the wholesale price for firm *i* in region *s* in year *t* as

$$p_{ist} = mc_{ist} + d(\zeta_{ist}) \tag{5}$$

where p_{ist} is the wholesale electricity price received by firm *i* in region s in year *t*, mc_{ist} is the marginal cost of electricity generation, and $d(\zeta_{ist})$ is a demand shock for firm *i* in region s in year *t*. Equation (5) is a familiar equation where price is equal to marginal cost, but potentially deviate from the marginal cost influenced by demand-side factors. I can decompose equation (5) into the regional mean $(mc_{st} + d(\zeta_{st}))$ that is common to all firms in region s in year *t* and the deviation from this mean that is firm-specific.

$$p_{ist} = (mc_{st} + d(\zeta_{st})) + (mc_{ist} - mc_{st} + d(\zeta_{ist}) - d(\zeta_{st})) \equiv (mc_{st} + d(\zeta_{st})) + (\triangle mc_{ist} + \triangle d(\zeta_{ist})) \equiv p_{st} + \triangle p_{ist} \quad (6)$$

where I use the mean of $\triangle p_{ist}$ for all firms but firm i in the same region s in period t, $\overline{\triangle p_{-ist}}$, to instrument Q_{it}. The idea is that after eliminating region-specific time-varying components that are common to all firms in a region, the price variations across the firms in region s in year t are driven by firm-specific shifters, which provide an instrumental variable that is correlated with Q_{ist} through the regional electricity demand but uncorrelated with the error term in the cost function C_{it} given that $\triangle p_{-ist}$ is induced by either marginal cost or demand shocks that are specific to individual firms $-i$.

In the estimation, I specify the log of the cost function in (4) as

$$\tilde{c}_{ist} = \gamma_0 + \gamma_1 \tilde{p}^m_{it} + \gamma_2 \tilde{p}^p_{it} + \gamma_3 k_{it} + \gamma_4 q_{it} + \gamma_5 q_{it} \cdot \text{Ownership}_i + \gamma_6 \text{Ownership}_i + \delta_t + w_{it} + v_{it} \quad (7)$$

where the small letters indicate the log of the variables. Since the productivity w_{it} is unobservable, equation (7) includes the two error terms, w_{it} and v_{it}, where v_{it} represents an i.i.d. error term in the estimation. Therefore, the coefficients in (7) are identified in the second stage if $\overline{\triangle p_{-ist}}$ is uncorrelated with the unobserved productivity w_{it} but correlated with q_{it}. I also control for industry-wide shocks using year fixed effects, δ_t. By including the ownership dummy, the specification in (7) allows that the returns to scale can be different across the ownership structures. Finally, by the duality theory, the cost function is homogenous of degree one in input prices. In equation (7), this is imposed by normalizing the material and purchased power prices (P^m_{it} and P^p_{it}) by the labor price (P^l_{it}), the log of which are represented by $\tilde{p}^m_{it}$ and $\tilde{p}^p_{it}$, respectively.

IV. Results

In this section, I start with the discussion of the performance outcome regressions. I then proceed to present the cost function estimation results where I quantify the marginal cost of operation across the ownership structures.

1. Differences in Performance Outcomes

Table 7 shows the results from the estimation of (2) for various performance outcome variables. In the column (1), the result for the cost of debt regression indicates that comparing between small cooperatives and small investor-owned utilities, small cooperatives have higher cost of debt than small investor-owned utilities by 1 percent. Having large plants increases the cost of debt for investor-owned utilities by 0.3 percent. Relative to large investor-owned utilities, cooperatives with large plants have higher cost of debt by 1.6 percent, suggesting that investing in large plants is more costly for cooperatives. The estimates are statistically signicant at 5 percent or stricter.

In the weighted average cost of debt and equity regression, in the column (2), the estimate for the interaction coefficient α_3 is positive and statistically significant at 1 percent. Even with the higher cost of debt partly offset by zero dividends, the weighted average cost of capital is still higher for large cooperatives than those counterparts by 1.5 percent. However, for small cooperatives the insignificant estimate α_1 indicates that the lower cost of equity effectively compensates the higher cost of debt, resulting in statistically indifferent weighted average cost of debt and equity.

The columns (3) to (6) present the regression results of the profitability outcomes, return on assets and return on equity. I do not find systematic differences between cooperatives and investor-owned utilities in these outcome variables. On the other hand, the coefficients for large plant are significant at 10 percent in the columns (3) and (4), by 1.3 and 1.8 percent, using net incomes after and before income taxes, respectively, which

〈Table 7〉 Comparison of rm performances between Cooperatives and IOUs

	Dependent variable						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coefficient on	COD	WACC	ROA-A	ROA-B	ROE-A	ROE-B	CU
Cooperative	0.01** (0.003)	-0.003 (0.003)	0.005 (0.007)	-0.006 (0.009)	0.35 (0.32)	0.32 (0.32)	0.01 (0.07)
Large plant	0.003** (0.001)	-0.011 (0.006)	-0.013* (0.007)	-0.018* (0.008)	0.11 (0.07)	0.11 (0.08)	0.05 (0.06)
Cooperative× Large plant	0.016** (0.007)	0.015** (0.003)	-0.016 (0.01)	-0.01 (0.01)	-0.74 (0.40)	-0.78 (0.43)	0.08 (0.17)
Firm controls							
Portion of sales for resale	-0.008** (0.002)	-0.006 (0.007)	1.01 (1.01)	0.01 (0.01)	0.37 (0.33)	0.42 (0.36)	0.09 (0.08)
Portion of electricity purchases	-0.002 (0.003)	-0.02** (0.008)	-0.01 (0.008)	-0.02* (0.009)	-0.11 (0.13)	-0.10 (0.13)	-0.41** (0.06)
Steam turbine	-0.61** (0.08)	-0.28 (0.22)	0.63 (0.45)	0.44 (0.50)	-2.22 (9.20)	-2.81 (9.37)	-4.05 (5.89)
Combustion turbine	0.61 (0.34)	-1.48 (1.09)	0.41 (1.06)	2.03 (1.23)	-41.01 (39.65)	-36.57 (41.68)	-42.18 (25.88)
Combined cycle	-0.41** (0.16)	0.0005 (1.17)	-0.97** (0.23)	-1.49** (0.27)	-0.35 (9.61)	-2.42 (10.45)	-7.86 (7.75)
Other	0.28 (0.88)	1.32 (1.58)	-1.23 (2.50)	-1.55 (3.65)	45.98** (19.78)	53.60* (23.73)	45.88* (24.40)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistic	10.73**	154.84**	813.50**	83.73**	1504.68**	49.29**	6680.13**
Observations	2149	2149	2135	2135	2135	2135	1325
R^2	0.29	0.04	0.09	0.11	0.06	0.07	0.48

Notes: Robust standard errors are clustered at the region in parentheses. Dependent variables are the performance outcomes presented in Table 5: COD is cost of debt, WACC cost of capital, ROA-A and ROA-B return on assets after and before income taxes, respectively, ROE-A and ROE-B return on equity after and before income taxes, respectively, and CU capacity factor.
** Signicant at 5 percent or stricter.
* Signicant at 10 percent.

indicate the differences in return on assets between small and large investor-owned utilities. The lower return on assets implies that relative to small investor-owned utilities, large investor-owned utilities generate lower net income given level of assets, or have excessive assets to generate given level of net income. Although it is not the scope of this paper, this is consistent with the hypothesis suggested by Averch and Johnson (1962) where regulated investor-owned utilities overinvest in capital under the cost of service regulation, as new investment in capital becomes part of the rate of return calculation allowed to investor-owned utilities. The column (7) presents the comparison of capacity utilization across the ownership structures. I do not find systematic differences between the two groups. Finally, Table 7 also shows that the firm control variables(X_{it}) are important determinants of the firm performance outcomes and well capture the individual heterogeneity. For example, in the column (1), an increase in the portion of sales for resale, i.e., the portion of sales in wholesale markets, decreases the cost of debt. The column (7) indicates that an increase in the portion of electricity purchases decreases the capacity utilization. In all the specifications, F-statistics reject the null that all of the region and year dummy variables are zero, suggesting that the fixed effects control some heterogeneity at the region given a year.

2. Differences in the Cost of Operation

The analysis in Section 4.1 revealed some systematic differences between cooperatives and investor-owned utilities. In particular, I saw that cooperatives operate under conditions of more constrained access to capital associated with higher cost of debt and limited availability of external equity. However, I did not find cooperatives are necessarily less profitable or efficient than investor-owned utilities. In this section I proceed to investigate whether there are any differences in the cost structure of operation across the ownership forms, and recover the marginal costs of operation.

Table 8 presents the results of the OLS estimation of the cost function in (7). As I note

〈Table 8〉 OLS estimation of the cost function

Coefficient on	Plant (1)	No plant (2)
q_{it}	0.76** (0.14)	0.90** (0.03)
q_{it} · Ownership$_i$	0.03 (0.08)	-0.007 (0.03)
Ownership$_i$	-0.12 (0.19)	-0.06 (0.11)
p_{it}^m	0.13 (0.11)	0.54** (0.14)
p_{it}^p	0.39** (0.12)	0.15 (0.12)
k_{it}	0.06 (0.07)	
Constant	0.72** (0.25)	0.84** (0.08)
Year fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
Observations	1364	651
R^2	0.92	0.94

Notes: Robust standard errors are in parentheses.
** Signicant at 5 percent or stricter.
* Signicant at 10 percent.

that about one-third of the firms in the data does not own power plants, I estimate the separate cost function for the firms that own generating capacity and those that do not own generating capacity. Table 8 shows the coefficient of q_{it} is 0.76 and 0.90 for plant owners and non-plant owners, respectively, suggesting positive scale economies for both plant and non-plant owners. The interaction term between q_{it} and Ownership$_i$ is not significant in both columns, nor is Ownership$_i$, implying that both the marginal and fixed cost of operation are not different across the ownership structures. However, as I discussed, if there is bias due to the correlation between q_{it} and w_{it}, the coefficients are imprecisely estimated.

Table 9 shows the results of the first stage regression using $\overline{\triangle p_{-\,ist}}$ as the instrument. The instrument is a strong predictor of the electricity output. For example, in the column (1), for every 10 percent increase in the mean of the competing firms' deviation from the regional wholesale price, electricity output for firm *i* increases by 0.5% and 1.2% for investor-owned utilities and cooperatives, respectively, which are statistically significant at 5 percent or stricter. In addition, the first stage F-statistics are large, suggesting that the instrument is not weak.

〈Table 9〉 First stage estimation of the cost function

	Plant		No plant	
	(1)	(2)	(3)	(4)
Coefficient on	q_{it}	q_{it} · Ownership$_i$	q_{it}	q_{it} · Ownership$_i$
$\overline{\triangle p^2_{-\,ist}}$	0.05** (0.01)	0.0002 (0.0006)	0.43** (0.03)	0.004 (0.004)
$\overline{\triangle p^2_{-\,ist}}$ · Ownership$_i$	0.07** (0.03)	0.07** (0.03)	-0.08 (0.09)	0.35** (0.09)
Ownership$_i$	-0.49** (0.14)	1.30** (0.21)	-0.98* (0.56)	-1.29** (0.43)
p^m_{it}	0.07 (0.04)	0.06** (0.01)	-0.29 (0.28)	0.08 (0.05)
p^p_{it}	0.18** (0.04)	-0.004 (0.004)	-0.29** (0.12)	0.02 (0.03)
k_{it}	0.48** (0.02)	0.007** (0.002)		
Constant	-1.09** (0.21)	-0.09** (0.03)	0.10 (0.40)	-0.17* (0.10)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	1298	1298	481	481
F-statistic	18.37	20.21	77.10	9.35

Notes: Robust standard errors are in parentheses.
** Signicant at 5 percent or stricter.
* Signicant at 10 percent.

〈Table 10〉 Second stage estimation of the cost function

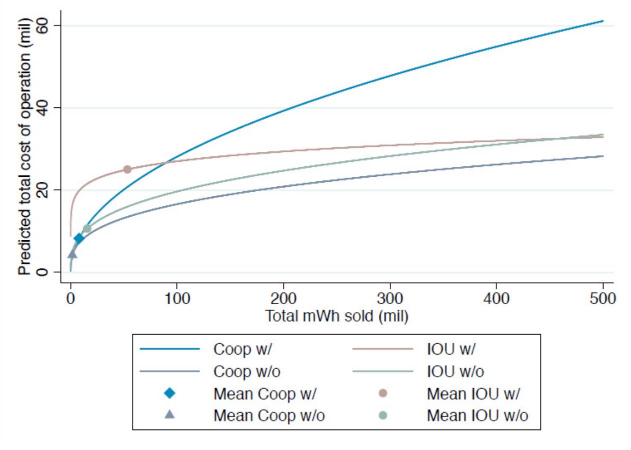
	Plant	No plant
Coefficient on	(1)	(2)
q_{it}	0.28* (0.16)	0.76** (0.76)
$q_{it}\cdot$ Ownership$_i$	0.83** (0.38)	-0.07 (0.07)
Ownership$_i$	-1.62** (0.68)	-0.17* (0.09)
p_{it}^{m}	0.15** (0.04)	0.54** (0.09)
p_{it}^{p}	0.48** (0.08)	0.18 (0.11)
k_{it}	0.28** (0.08)	
Constant	0.29 (0.18)	1.04** (0.12)
Year fixed effects	Yes	Yes
Observations	1298	481
F-statistic	107.79	154.07

Notes: Robust standard errors are in parentheses.
** Signicant at 5 percent or stricter.
* Signicant at 10 percent.

The second stage results of the cost function estimation are presented in Table 10. It is interesting to note that the coefficient of q_{it} moves downward, while that of the interaction term $q_{it}\cdot$ Ownership$_i$ moves upward in both columns, suggesting that bias induced by the simultaneity between q_{it} and $\tilde{c}_{it}$ has different directions for cooperatives and investor-owned utilities. The upward bias would arise if the correlation between q_{it} and w_{it} has the same sign with the correlation between $\tilde{c}_{it}$ and w_{it} in equation (7). In contrast, the downward bias would arise if the two correlations have the opposite signs. Let us assume that there is a positive simultaneity between q_{it} and w_{it} in both types of ownership structure, i.e., more productive firms sell more electricity, either by producing in their plants or by purchasing from wholesale markets. Since the output coefficient moves downward for investor-owned utilities in Table 10, I expect that there is a positive relationship between $\tilde{c}_{it}$ and w_{it}, i.e., more productive firms incur higher cost of operation holding output at constant. This is possible if more productive firms sell more outputs but there exists inefficiency associated with cost of operation in the firms, e.g., suboptimal allocation of inputs, which lead to increased cost of operation. Or, efficiency could be negatively affected if there was market power exercised by some firms in the market, which would typically be large firms.

As Joskow (1997) discussed, this result may support that very large electric companies are not neccesary to exploit the economies of scale available in the industry. The cost efficiency of operation would rather depend on the ability to coordinate power plants and transmission network dispersed over geographic areas. The marginal cost estimates that will be discussed below also show that the marginal cost of operation is virtually at once the output level reaches a certain point. In contrast to investor-owned utilities, I find the coefficient moves upward for cooperatives in the IV regression, i.e., the estimate is biased downward in the OLS estimation. Thus I expect that there is a negative relationship between $\tilde{c}_{it}$ and w_{it}, suggesting that more productive cooperatives incur lower costs of operation holding the output levels at constant. Note that it is not inconsistent with the results in columns (3) and (4) of Table 7, where I found large investor-owned utilities have lower ratio of net income in total assets than small investor-owned utilities.

The column (1) in Table 10 also suggests that the fixed cost of operation, indicated by different intercepts across the ownership structures, Ownership$_i$, is lower for cooperatives, whereas the marginal cost of operation q_{it} Ownership$_i$ more sharply increases with the output for cooperatives relative to investor-owned utilities. In contrast, in the column (2) where I estimate the cost function of non-plant owners, I still find the fixed cost of operation is lower for cooperatives, but the marginal cost structure is not different between the two ownership types. In both cases, the results show that the electric power industry is characterized by substantial positive scale economies with the magnitude of 0.28 and 0.76 for plant and non-plant owners, respectively, except that I cannot reject the constant returns to scale for cooperatives with power plants. Figure 1 evaluates the cost function using the IV estimates over a range of electricity outputs for each of ownership structures while holding other variables at the sample means. Each of the dots in Figure 1 represents the mean of the total costs of operation and the electricity output in each group. The scale economies persist for large investor-owned utilities. Moreover, the sample mean of large investor-owned utilities operate in the fiat area of the cost curve.



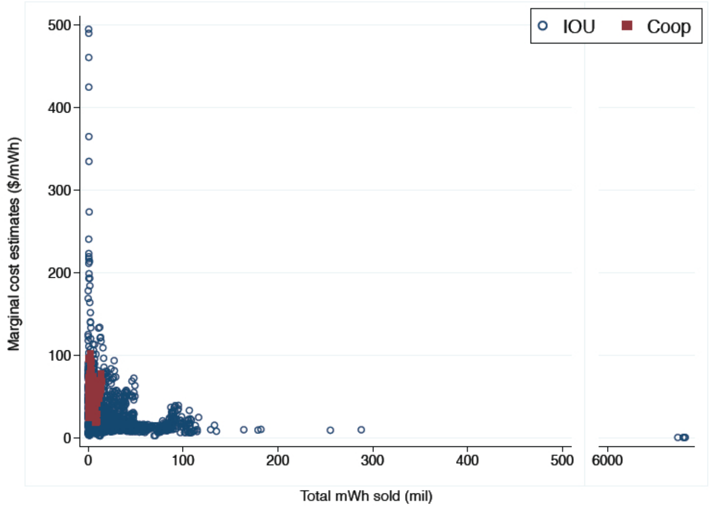
〈Figure 1〉 Predicted total cost function

〈Table 11〉 Marginal cost estimates

	Cooperative		IOU	
	No large plant	Large plant	No large plant	Large Plant
Marginal Cost ($/mWh)	49.56 (17.98)	48.57 (15.05)	40.92 (42.94)	17.07 (18.41)
Observations	118	67	913	1089

Notes: Standard deviations are in parentheses.

Table 11 uses the coefficient estimates from the IV regression to calculate the marginal cost of operation at the firm-level, specically, $\gamma_4 \frac{q_{it}}{\tilde{c}_{it}}$ and $(\gamma_4 + \gamma_5) \frac{q_{it}}{\tilde{c}_{it}}$ for investor-owned utilities and cooperatives, respectively. The marginal costs of operation are substantially lower for large investor-owned utilities. Figure 2 shows the plot of the marginal cost of operation estimates over a range of electricity output sold by the firms. The marginal cost of operation quickly decreases for the firms at low levels of output, but it is almost fiat once the output becomes greater than around 100 mil mWh. Note that comparing cooperatives and investor-owned utilities at the same output levels, cooperatives do not necessarily show higher marginal costs of operation. Finally, in Table 12, I regress the marginal cost estimates using the specification in (2), and find the large plant ownership do not lead to the marginal cost savings for cooperatives, whereas the marginal cost of operation decreases by 8.95 $/mWh on average for large investor owned utilities relative to small investor-owned utilities.



〈Figure 2〉 Marginal costs distribution

〈Table 12〉 Dierences in marginal cost of operation across the ownership structures

Coefficient on	MC_{it}
Cooperative	7.81 (10.63)
Large plant	-8.95** (3.80)
Cooperative · Large plant	5.13 (12.43)
Constant	14.59** (6.32)
Firm controls	Yes
Region fixed effects	Yes
Year fixed effects	Yes
Observations	2138
R^2	0.33

Notes: Robust standard errors are clustered at the region in parentheses.
** Significant at 5 percent or stricter.
* Significant at 10 percent.

V. Conclusion

This paper investigates performance differences of cooperatives relative to investor-owned utilities in the U.S. electric power industry. Using a panel data of firms from 2001 to 2014, I find large investor-owned utilities take benefits of substantial scale economies that exist in the industry over a broad range of outputs. However, the estimation of the cost function shows the marginal cost of operation is virtually fiat once the electricity output reaches a certain amount, suggesting that very large electric firms are not necessary to exploit the economies of scale available in the industry.

In contrast to investor-owned utilities, I find the marginal cost of operation substantially increases with the amount of output for cooperatives. Cooperatives also operate under conditions of more constrained access to capital, associated with higher cost of debt and limited access to external equity. While the higher cost of debt is compensated by lower cost of equity for small cooperatives, large cooperatives still face the higher cost to finance their assets even after taking the lower patronage dividends into account. In particular, cooperatives rely on higher portion of long-term debt to finance their assets, implying that cooperatives borrow in order to invest in capital, such as plants, whereas investor-owned utilities make use of short-term liabilities to finance their current operations.

I do not find performance differences in profitability between the two ownership structures, which is measured by return on assets and return on equity. Utilization of plant capacity is also not statistically different across the ownership structures. There are a number of potential directions for future research. First, I have not considered the endogenous determination of ownership structure. It was not the most important in the sample given that ownership structures were predetermined, as electric cooperatives were emerged initially driven by the policy in 1930s to serve rural areas. Since the ownership structure was predetermined in the data, I looked at the performance differences conditional on the choice of ownership structure. However, since the ownership structure is eventually an endogenous outcome of decisions, a formal model that describes the decisions will be needed to explain the relation between the ownership and the firm performances. Second, I have not modeled the effects of competition and market structure. As I discussed, the regulations and market structures are heterogeneous particularly for investor-owned utilities. It would be possible for us to distinguish among these factors if more detailed data is available. Finally, although it was not the scope of this paper, it would be interesting to examine the incentives for cooperatives to make decisions on the power plants ownership. Specifically, the results point out that the plants ownership is more costly for cooperatives, whereas it does not necessarily increase profitability of the firms. One possible explanation could be the benefits obtained from the plants ownership pass through the member distribution cooperatives, which was not captured in the data. In the future research, I am going to construct a sample of distribution cooperatives that are either vertically integrated with their Generation and Transmission cooperatives or not integrated, and examine the effects of vertical integration on performances, e.g., the price-cost margins or the efficiency of the distribution cooperatives.

[References]

Arocena, P., D. S. Saal, and T. Coelli, "Vertical and Horizontal Scope Economies in the Regulated U.S. Electric Power Industry," *The Journal of Industrial Economics*, Vol. LX, No. 3, 2012, pp. 434~467.

Atkinson, S. E. and R. Halvorsen, "The Relative Efficiency of Public and Private Firms in a Regulated Environment: The Case of U.S. Electric Utilities," *Journal of Public Economics*, Vol. 29, 1986, pp. 281~294.

Averch, H. and L. L. Johnson, "Behavior of the Firm Under Regulatory Constraint," *American Economic Review*, Vol. 52, No. 5, 1962, pp. 1052~1069.

Braguinsky, S., A. Ohyama, T. Okazaki, and C. Syverson, "Acquisitions, Productivity, and Profitability: Evidence from the Japanese Cotton Spinning Industry," *The American Economic Review*, Vol. 105, No. 7, 2015, pp. 2086~2119.

Claggett, E. T., D. R. Hollas, and S. R. Stansell, "The Effects of Ownership form on Profit Maximization and Cost Minimization Behavior within Municipal and Cooperative Electrical Distribution Utilities," *Tue Quarterly Review of Economics and Finance*, Vol. 35, 1995, pp. 533~550.

Davis, L. W. and C. Wolfram, "Deregulation, Consolidation, and Efficiency: Evidence from U.S. Nuclear Power," *American Economic Journal: Applie Economics*, Vol. 4, No. 4, 2012, pp. 194~225.

Fabrizio, K. R., N. L. Rose, and C. D. Wolfram, "Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency," *The American Economic Review*, Vol. 97, No. 4, 2007, pp. 1250~1277.

Greer, M. L., “Can Rural Electric Cooperatives Survive in a Restructured U.S. Electric Market? An Empirical Analysis,” *Energy Economics*, Vol. 25, 2003, pp. 487~508.

Hueth, B. and P. Marcoul, “Agents Monitoring Their Manager: A Hard-Times Theory of Producer Cooperation,” *Journal of Economics & Management Strategy*, Vol. 24, No. 1, 2015, pp. 92~109.

Joskow, P. L., “Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector,” *Journal of Economic Perspectives*, 1997, Vol. 11, No. 3, pp. 119~138.

Joskow, P. L., “The Difficult Transition to Competitive Electricity Markets in the U.S.,” *MIT Center for Energy and Environmental Policy Research,* 2003.

Koh, D. S., S. V. Berg, and L. W. Kenny, “A Comparison of Costs in Privately Owned and Publicly Owned Electric Utilities: The Role of Scale,” *Land Economics*, Vol. 72, No. 1, 1996, pp. 56~65.

Kwoka, J. and M. Pollitt, “Do Mergers Improve Efficiency? Evidence from Restructuring the U.S. Electric Power Sector,” *International Journal of Industrial Organization*, Vol. 27, 2010, pp. 645~656.