Transaction Costs, Agency Theory and The Complexity of Electric Power Distribution Governance

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1. Electric Distribution

Electrification provides citizens unique empowerment, creates economic opportunities, reduces poverty, and allows democratic ideals to be realized. Developing nations transitioning from state owned enterprises, SOEs, to investor owned utilities, IOUs, have typically sought to realize increased efficiencies and performance to offset necessary returns to investors. SOEs have been plagued by accountability problems, inability to manage operations, and financed operations through customer revenues. IOUs promised to provide highly efficient firms, which would produce economic advantages and alleviate widespread poverty.

That expectation failed to fully materialize, this failure partly resulted from regulatory difficulties (i.e. problems in controlling the behavior of monopolistic investor owned electric utilities). These difficulties centered on the firm's ability to gain advantage over regulators by providing asymmetric information. Asymmetric information disadvantages regulation by preventing the regulator from observing true efficiencies and true cost structures, while allowing the firm to obtain increased profits from reduced efforts. The regulated utility's ability to capture regulators through the use of incomplete knowledge is well known (Joskow 2000, 2003, 2005, Etzioni, 1986; Henisz and Zelner, 2002; Peltzman, 1989; Stigler and Friedland, 1962, and Vogelsang, 2004).

The IOU focuses on wealth creation for its investors while the regulator's task is to maximize consumer welfare. As the regulator attempts to persuade the utility to act on behalf of the principal through incentives, a competitive game of principal and agent develops. The IOU desires wealth maximization with least cost and least effort. The firm responds to societal benefits only as those benefits relate to the firm's goal of profit maximization. The regulator conversely is desirous of inducing the IOU to balance profit maximization with societal benefits and value to the consumer. This is a tension, which is inherently problematic.

A second private utility ownership configuration exists, which although is more difficult to create, results in a more desirable governance and ownership structure. This better structure is achieved by overcoming the principal-agent dilemma created between regulators and IOUs. The structure is that of a cooperative or COOP. In a cooperative the consumers of the electric power are the owners and form the governance structure through a democratic process. While the IOU firm's mandate focuses on wealth creation to the utilities owners, the cooperative focuses on value creation for its stakeholders (i.e. owner-consumers). Consumer-owner governance eliminates the divergent interests between owners and consumers of the IOU. In a cooperative no advantage exists for the cooperative to provide asymmetric information to itself. Rather, an incentive exists to use the firm's knowledge and capabilities to maximize its value to the stakeholders and to do so at least cost. The cooperatives governance is from the beginning aligned with consumer/owner needs and incorporates explicit goals to provide societal benefit hence removing most of the need for regulatory oversight.

The efficiency advantage of rural electric cooperatives in the United States and those in developing nations has been well established (American Public Power, 2006; EIA-RUS, 2004; NRECA, 2006). The predominant problem preventing widespread establishment of electric distribution cooperatives arises from the lack of financial reward to champions expending resources to advance this type of ownership. Unlike with investor ownership a cooperative champion is unable to recover in excess of that of other owner-consumer stakeholders. The present article examines the electric distribution cooperative model through use of agent-based modeling to compare governance structures and societal benefit levels between the cooperative and the IOU.

A major issue in electric power distribution is the IOU's relationship to the regulator. Ideally, regulators develop incentive strategies chosen by the principal which balance wealth maximization of the firm with societal benefits of the consumers. In this paper we examine simulating these two contrasting governance structures, and assuming heterogeneous agents, we show that there are locally stable equilibrium performance levels determined by the differences in governance.

Few commodities are more basic than electric power and fewer commodities are provided in such a complete absence of competition. Electricity is without alternative, cannot be efficiently stored, and is delivered via a monopolist infrastructure. As a result many nations have developed public agencies to own and operate their electric power infrastructure. Government inefficiencies and the inability of most governments to provide continual subsidies has resulted in widespread electric privatization over the last two decades. During this process consumers have experienced very mixed success. Only when privatization has failed to provide investors with an acceptable return on investment have cooperatives been formed in

order to privately supply electric power to consumers. In general where investors were willing to risk capital IOU's were created. However, cooperatives have been formed in developing countries, in a similar fashion as occurred in the United States in the first half of the 20th century, when expected returns prevented IOU's from investing and citizen groups took the initiative themselves.

IOU investment is based on shareholders receiving a suitable perceived return on their investment. Governments have accepted IOU's receiving this "suitable return" in exchange for capital investment, the transfer of knowledge, and the promise of increased electric power distribution efficiencies. However regulation of IOUs is always difficult, especially in developing countries where greater information asymmetries frequently occur, typically resulting in higher rents and less than optimal performance.

Cooperatives conversely do not require profits to be transferred to owners nor do they benefit from less than optimal performance. In the United States investor owned electric utilities supply the greatest share of the US electric market. Public power and cooperatives each supply approximately 12% of the United States market. Internationally, approximately 250 cooperatives serve 34 million people in 15 countries.

2. Governance Models Of Private Electric Utilities

This paper contrasts two private governance structures; that of investor ownership and that of cooperative ownership. Public ownership, SOEs, which is not considered in this study is generally considered to perform less efficiently than private ownership, and SOEs are increasingly being transferred to private firms. The organizational principle of the IOU is to create shareholder wealth by creating surplus rents (profits) for the services provided. Shareholders generally do not purchase electricity from the firm and are concerned with the value offered to customers only to the extent that the value increases shareholder wealth.

Table 1. Governance Comparisons of Cooperative And Investor Owned Utility Structures

Structural Comparison Of Cooperatives and Investor Owned Utilities

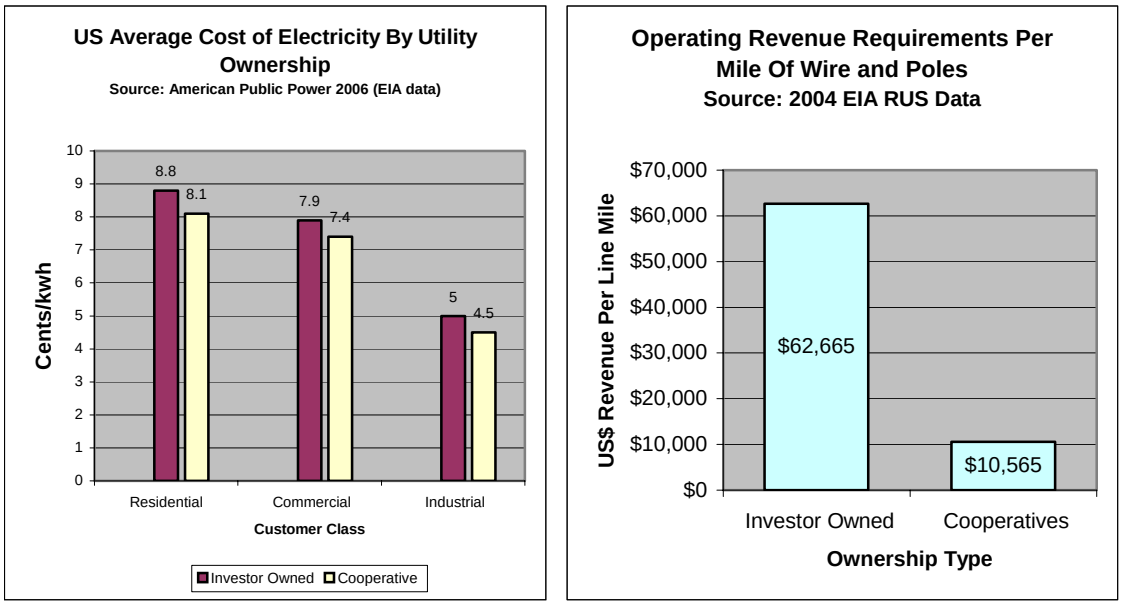
CHARACTERISTIC	COOPERATIVES	INVESTOR-OWNED CORPORATIONS
STRUCTURE		
Organization Principles	Based on Value Creation for Members Follow Rochdale Principles	Operate to create shareholder wealth
Ownership	Owned by members—those that purchase electricity and services of the cooperative.	Owned by outside shareholders who may or may not purchase electricity and services of the firm.
Control	Democratically controlled by the members Vote based on membership one vote- one member not on service usage	Controlled by shareholders according to their investment share. Shareholders must control threshold ownership to influence decisions
GOVERNANCE		
Board Membership	Co-op members directly elected by the members. Directors are generally independent without business relationship separate from other members. Directors not selected by CEO but rather by members through selection process Management typically does not hold board seats.	Independent directors, management and other directors with financial or business involvement in the firm. CEOs often serve as board chair.
Board Compensation	Cost reimbursement for attending board meetings. Board members typically uncompensated volunteers.	Receive significant financial compensation.
Board Selection	Candidates are nominated by membership either directly or by nominating committees. Typically involve call for nominations from members. Ballot includes all nominated candidates. Members allowed to nominate any director-candidate Candidates by petition require small threshold of signatures (100 or 1% of membership)	Nominations by the board of directors and management. Selection process internally controled by management and existing BOD in control Board proxy materials include only board nominees. Limited ability for shareholders to nominate board members and must use a separate proxy at their private expense Shareholders execute separate proxy to vote for other candidates Companies rarely nominate candidates brought by shareholders
Board Elections	Board elected directly by members by one-member, one vote basis. Contested elections are the norm, not the exception. Members vote in advance or at annual meeting	Elections serve as a "ratification" of uncontested management/ board-selected slate offered on the proxy statement. Shareholders vote by proxy
Accountability	Board directly accountable to members through election process. Directors easily replaced by membership	Director election process affords limited oversight to shareholders Difficult and costly for shareholders to remove directors
FINANCIAL		
Dividends	Profits earned are reinvested in the business and/or returned to members as patronage payments and/or used to reduce costs of service.	Profits returned to shareholders and/or reinvested in business increasing business value.
Motivation	Maximize member-service	Maximize shareholder returns.

Conversely, cooperative owners are those who directly receive service benefits from the utility. Rents in excess to costs while providing wealth creation for shareholders (profits), provides benefits only to the extent that those rents retire debt and finance improvements such as line extensions. Under regulation, IOUs are provided a margin over costs. Under cost of service regulation little incentive exists to expend knowledge and investment in order to become more efficient and there is a counter-incentive whenever this would reduce margins or profits by comparison. Cooperatives create value by providing the best service for the least cost. The democratic nature of the cooperative governance structure insures proper responses to the needs of the citizenry and allows the firm to strive for high efficiency at the same time providing no incentive or ability for special interests to gain advantage.

3. Governance Competitive Advantages

In the presence of well-developed capital markets with efficient structures, both investor owned utilities and cooperatives tend towards marginal cost, resulting in similar operating costs and efficiencies. While capital markets possessing information symmetry exist in most markets, internal information symmetries and competition do not. This lack of competition allows investor owned utilities to provide asymmetric information to regulators, representing the firm as less efficient than it actually is. By providing asymmetric information a fundamental divergence is portrayed with respect to the actual operating efficiencies of the IOU compared to the expected operating efficiency as viewed by the regulator. This difference in information allows the IOU to receive a higher return for operating poorly than it would have received from operating efficiently.

Figure 2. Comparative Operating Efficiencies For Cooperative and Investor Ownership.



In contrast, a cooperative attempts to operate as efficiently as possible. As a result, electric distribution cooperatives on average outperform investor owned firms both in terms of consumer costs and in revenue requirements. This difference is reflected in the United States by data compiled by the US Energy Information Administration[1]. DOE-EIA data for 2004 reports US cooperatives require on average $10,565 per line mile to own and operate their systems and have an average of 7 customers per mile. Investor owned utilities, by comparison, requires revenues on average of $62,665 per line mile with 35 customers per line mile. US cooperatives achieve this high performance by operating 43% on the US distribution system while only distributing 10% of the nations power supply to 12% of the nation's customers. US

[1] The US EIA reports operating data for the 223 investor owned utilities and the 885 cooperatives operating in 50 states and the District of Columbia annually.

cooperatives even with a customer density of only 16% of that of investor owned utilities and with customers requiring 22% less power, still deliver power to their customers at a lower cost per kilowatt-hour than investor owned utilities[2]. This revenue requirement differential is staggering. US cooperatives operate their systems for 17% of the cost per line mile required by IOUs.

In the United States with its rapid information transfer and highly developed regulatory structure, regulators are unable to insure IOU performance, developing nations with less access to information and less sophisticated regulatory structures have little hope in compelling IOU performance and avoiding regulatory capture.

Table 1 Comparison of US Based Distribution Electric Utility Types

	Investor-Owned	Publicly Owned	Cooperatives	Total
Number of Organizations	220	2,000	930	3,150
Number of Total Customers	99 m	20 m	17 m	136 m
Size (median number of customers)	395,000	1,900	12,000	
Customers, % of total	73%	14%	12%	100%
Revenues, % of total	75%	14%	10%	100%
kWh sales, % of total	75%	15%	10%	100%
Sales (billions kilowatt hours)				
Residential	900	190	200	1,290
Commercial	963	198	69	1,230
Industrial	698	148	77	923
Other	3	3	0	6
Total	2,564	539	346	3,449
Miles of Distribution Line	50%	7%	43%	100%
Customers per mile of line (density)	35	47	7	33.9
Revenue per mile of line	$62,665	$86,302	$10,565	$60,827
Distribution plant per Customer	$2,229	$2,309	$2,845	$2,362
Assets (billions)	$660	$162	$92	$914
Equity (billions)	$181	$50	$28	$279
NRECA Updated January 2006, Source EIA RUS data, CFC				

4. Agent Based Model Development

The role of regulators is examined below by a model, which assigns the regulator the role of principal and the utility the role of agent. It has been assumed that the regulation scheme is identical for both governance structures, (i.e. it is designed to move the utility to create value for the customer and move the firm to perform near its marginal costs). Requiring the principal to employ he same incentive scheme for both the IOU and the COOP governance structure allows one model to be developed and compared for both kinds of service providers. The difference in the model is exemplified by how different agents react to the mandates of the principal. The IOU governance mandates wealth creation for its shareholders. The cooperative governance mandates value creation to customers. To achieve this objective, the IOU provides

[2] In the United States 885 distribution cooperatives (not including generation, transmission, and statewide electric cooperatives) provide reliable service to 37 million Americans in 47 states, own $86 billion in assets, and maintain 2.4 million miles or 43% of the nations distribution lines covering 75% of the nation's land mass.

the regulator asymmetric information in order to gain a competitive advantage with respect to return on capital.

The regulator, who is unable to determine the utility's actual individual performance and efficiency characteristics, here defined as firm type θ, employs a strategy to represent itself as type θ^-. The firm by representing itself not has having performance characteristic of type θ but rather as a less efficient utility of type θ^- the firm is able to obtain a rate of return based on inflated costs of operation. When successful the utility receives a higher actual rate of return that the regulator sees with less effort. In this model, regulators are unable to compel neither optimum results nor cost minimization. The regulator understanding this, delegates him to providing incentives by which the firm may increase profits by operating more efficiently. Although intentionally producing utility surpluses, base performance and efficiencies are also increased reducing the gain from regulatory capture.

Conversely, cooperative owned firms, are customer value driven and strive not only to disclose the utilities actual performance characteristics, again defined as firm type θ, but the cooperative strives on its own to increase efficiencies and performance to become a utility with characteristics defined as θ^+. Thus unlike the IOU, the cooperative's customer value driven governance structure bypasses the regulator and moves on its own toward optimum operations and cost minimization.

A Bayesian approach in assigning the regulator as the principal and the firm as the agent allows an evaluation of the regulator's control over the activities of the electric distribution firm. The regulatory objective of maximizing consumer value as a function of cost is maintained in comparing the two governance configurations. Consumer welfare becomes the value received by the consumer for services provided minus the inefficiencies and profit required by the firm to achieve this level of benefit. Welfare becomes W(c) where "c" represents a level of cost, value received becomes a function of cost V(c) and the welfare is then reduced by inefficiency "μ" and a factor representing the surplus rent (profit) "α".

$$W(c) = V(c) - [(1+\mu)(1+\alpha)-1](c)$$

For the cooperative, no profit or revenues are returned to the owners and no incentive exists to maintain inefficiencies. Thus, W(c) = V(c). The differential between a cooperative and IOU becomes – $[(1+\mu)(1+\alpha)-1](c)$. Only in the case where the IOU efficiencies exceed the performance of a cooperative in excess of the profit does the IOU provide advantage. In practice this is likely to occur only if the cooperative is unable to obtain the necessary capital to operate.

The difficulty for regulators to access the utility's actual efficiency defined as type θ, combined with the utility's ability to mimic a less inefficient utility and earn positive profits without the knowledge of regulators is included in the model. Regulated return on equity and incentive compatibility constraint returns are included in the second surplus rent term. The incentive capability constraint (Vogelsang 2005) results in more efficient firms preferring high-powered incentives such as price caps and low efficiency firms preferring incentives such as profit sharing and rate of return regulation. In cases where asymmetric information prevents regulators from observing true costs and societal benefits capture is a real problem requiring limits on regulatory commitments.

Domah and Pollitt (2000) have advanced agent based model by expanding on the earlier work of Galal, Jones, Tandon, and Vogelsang (1994) and that of Newbury amd Pollitt (1997). They identify three main groups: consumers, producers, and government. Adapting their methodology to compare IOUs with cooperatives differential societal values can be measured. In this model the welfare penalty of investor ownership is expressed as

$$\Delta W = V_{si} - V_{sc}$$

V_{si} = societal value of IOU operation
V_{sc} = societal value of cooperative operation

Based on U. S. Department of Energy data, ΔW would be negative and would represent the societal premium resulting form the combination of asymmetric information and regulatory profits of the IOU compared to cooperative ownership. This model recognizes that efficiency and surplus rent savings are cumulative and as efficiencies are increased in the cooperative model and as debt becomes paid the moving average differential between the two different types of service providers increases.

5. Vogelsang's Bayesian Incentive Scheme Approach To Agent Based Models

Vogelsang (2005) has advanced a Bayesian approach in the prediction electric transmission pricing. He demonstrates the effects of performance-based regulation by adapting a Bayesian incentive

scheme to the agent-based model. His model again identifies the governmental regulator as the principal (used the privately owned electric firm as the agent in order to fulfill the government's objective of providing the consumer value). Again the basis for evaluation is the degree to which the principal maximizes consumer welfare. Consumer welfare is defined as the consumer surplus (value in excess of utility) plus an efficiency function of the firm's profit.

$W(c) = V(c) + \alpha\pi(c)$

Where $V(c)$ is the consumer surplus and α is a weight between 0 and 1 and $\pi(c)$ is the firm's profit. The result is a monetary transfer by which the regulator (principal) induces the firm (agent) to act in the consumer's interest. The regulator, in exerting monetary control over the firm, controls both the firm's behavior and the firm's financial flows. Following the assumptions of Vogelsang the firm's profit can be weighted by $\alpha \leq 1$, and the impact on the regulators budget can then be weighted as 1.

As the IOU provides the regulator asymmetric information, the agent gains advantage by misrepresenting the firm's type θ as type θ^- in order to increase its profits. In the absence of symmetric knowledge, the regulator suffers from capture and is unable to correctly determine the firm's type and thus unable to require optimum performance directly. The agent firm acts in its own self-interest, to maximize the monetary transfer $\Pi(T(c),c) = \pi(c) + T(c)$ at the beginning of this non-cooperative principal-agent game. The principal regulator seeks to cause the agent to increase its performance and efficiency by imposing two constraints. The agent will only respond favorably to the principal's interest if rewarded by a monetary reward at least equal to its reserve utility. The participation constraint, PC, will only be initiated if the value of participation equals or exceeds the costs and efforts of participation. For simplicity, the value can be set to a minimum resulting in the participation constraint being normalized to zero. The constraint then becomes

PC: $\Pi(c(\theta),T(c(\theta) \geq 0$

With the second constraint, the agent attempts to maximize its utility through incentives provided by the principal. Here the principal imposes an incentive compatibility constraint (ICC) to better insure that the incentive is based on the agents actual distribution of the agent. The agent will conversely attempt to maximize its own interest by mimicking a less efficient type θ^-, so that by exercising less effort the firm may obtain the same profit and obtain the same transfer. Thus by mimicking type θ^- a type θ or even a type θ^+ utility could obtain additional profit from the reduced costs and efforts.

ICC: $M\Pi/M\theta = -\psi'(e(\theta))$

Using the approach advanced by Vogelsang, as defined above, the unobserved firm type is θ, the unobserved firm effort is e, and the unobserved cost of the effort is $\psi(e)$. The regulator will attempt to maximize consumer value by developing incentive schemes while the IOU firm attempts through asymmetric information to take advantage of incentives to earn additional profit. Vogelsang defines the principal (regulator) attempt to maximize consumer value through a monetary transfer initiated to induce the firm to act in the principal's interest T(c) as:

$T(c) = \text{argmax } I_\theta[V(c(\theta) + \alpha\pi(c(\theta)) + (\alpha - 1)T(c(\theta))] f(\theta)d\theta$

Thus, corporate governance forms the basis for decision making in the regulated electric distribution industry. In the case of the cooperative governance the model simplifies to $T(c) = \text{argmax } I_\theta[V(c(\theta)] f(\theta)d\theta$. With the differential benefit being expressed as $T(c)-V(c) = \text{argmax } I_\theta[\alpha\pi(c(\theta)) + (\alpha - 1)T(c(\theta))] f(\theta)d\theta$.

6. Summary

The importance of providing electric power more efficiently to those with limited electric power and the importance in providing access to the estimated 1.6[3] billion persons without any access to electricity demands development and deployment of the most cost effective solutions. Higher electric costs translate directly too less economic development and more poverty. The principal-agent model presented develops a methodology for policy makers to measure of the expected penalty consumers will face resulting from an IOUs ability of regulatory capture, ability to provide asymmetric information, and profit

[3] The persons without electric power presented in the presentation by Robert Socolow to the World Bank in his presentation entitled Stabilization Wedges: Mitigation Tools for the Next Half Century on March 6, 2006.

requirements. The revenue requirements of an IOU over those required by a cooperative translate directly to reduced access, reduced economic development and reduced alleviation of human suffering. Policymakers and stakeholders therefore have substantial vested interest to consider and advance cooperatives as an alternative whenever the opportunity arises. This paper provides a foundation for this discussion.

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