# Network Regulation through Ownership Structure: An Application to the Electric Power Industry*

Federico Boffa[†] Lynne Kiesling[‡]

August 14, 2006

**Abstract**

We propose, describe, and model a competitive joint venture (CJV) institution as an alternative to traditional natural monopoly regulation of the wires portion of the electricity supply chain. This CJV institution consists of an ownership rule and a wires access charge determination rule, with wires use and control rights determined by a firm's market share in the downstream retail market. The wires use rights constitute an alienable property right. By exploiting the vertical structure of the electricity supply chain, this CJV institution can generate superior static and dynamic efficiency results in a model presented and analyzed here. The role of the regulator is one of *ex post* contractual enforcement; thus this institution is not prone to the information problems associated with traditional natural monopoly regulation. We demonstrate that first-best efficiency characterizes equilibrium in a pricing model without investment, and that first-best efficiency characterizes the equilibrium of the model with an investment process included under full-information assumptions.

## 1 Introduction

Two fundamental problems arise in natural monopoly and its regulation. The incentives for monopoly behavior inherent in the sole ownership of assets with economies of scale and asset specificity can lead to high prices, reduced output, and deadweight loss; this problem

*We would like to thank Ron Braeutigam, Fabio Braggion, Jim Dana, Reinout DeBock, Ivan Fau, David Haddock, Jakub Kastl, John Panzar, Martin Peski, Salvatore Piccolo, David Porter, Stephen Rassenti, Vernon Smith, Michael Whinston, Dean Williamson, Samantha Zyontz, and seminar participants at the Interdisciplinary Center for Economic Science at George Mason University for their helpful comments. We are very grateful to Zahra Siddique and Kristle Kilijanczyk for valuable research assistance, and to the Searle Fund for Policy Research and the International Foundation for Research in Experimental Economics for supporting this research. All remaining errors are ours alone.

[†]Northwestern University and Free University of Bolzano

[‡](contact author, lkiesling@northwestern.edu) Northwestern University and Interdisciplinary Center for Economic Science at George Mason University.

has traditionally led to rate-of-return regulation of network infrastructure industries in the United States. However, such regulation itself poses a problem due to the dispersed and private nature of information and knowledge, and the resulting impossibility of (first-best) optimal regulation. Thus the inability of reglators to observe actual operating costs can lead to distorted incentives, and a regulated environment can also lead to deadweight loss.

These problems apply directly to the electric power industry, and its nascent restructuring and move toward more market-based operations (at least in the wholesale exchange of power) has made consideration of these problems all the more obvious and pressing. As generation has become more competitive, and retail service is becoming increasingly competitive, the wires (transmission and distribution) become the sole remaining natural monopoly portion of the supply chain. Management and regulation of the wires is a current policy topic; while ownership of the wires remains concentrated in existing utilities, management and operational control of the transmission wires is vested in Regional Transmission Organizations (RTOs) or Independent System Operators (ISOs) in several regions in the U.S. As more wholesale transactions cross those ownership boundaries, two concerns have arisen: monopoly pricing of wires access, and the incentives presented to transmission owners to invest in the wires infrastructure. The policy response in the U.S. to concerns about monopoly pricing has been to follow the lead of the telecommunications industry and implement transparent open access pricing, implemented by such federal rules as FERC Order 888. The perceived lack of investment in the wires infrastructure hit a crescendo in August 2003, when a large cascading blackout removed service for most of the Northeastern U.S. and parts of Canada. One estimate of the capital cost of keeping up with demand growth over the next 20 years is 384 billion dollars (PNNL 2003, p. 10). Furthermore, this lack of investment has led to the aging of the wires network; the wires network remains an analog system, with the only true digital capability residing in control room operations and without any ability to perform digital monitoring or other network activities that use digital and communications technology.

Wires networks also display two types of asset specificity - transaction specificity and site specificity - because each wire is currently used only to distribute electric power and can only physically be in one, fixed, place.[1] In many industries firms integrate vertically to internalize Pareto-relevant externalities and to avoid possible holdup and opportunism problems that can arise from asset specificity (Williamson 1975).[2] In such cases integration occurs within firms to economize on transaction and coordination costs, as opposed to occurring through bilateral contracting in markets (Coase 1937). In the case of electric

[1] A new technology, broadband over power lines (BPL), is beginning to change the transaction specificity of the network assets, but its development and implementation at this point is limited.

[2] Buchanan and Stubblebine (1962) make the precise distinction that Pareto-relevant externalities are those that lead outcomes to be different from what they would be in a first-best equilibrium. In many discussions and policy applications this distinction has gotten lost, leading to erroneous arguments that all externalities must be internalized in a first-best equilibrium.

power distribution, however, the risk of hold-up is mitigated by the presence of a large number of users, either the retailers when the distribution service is separated from the retail service, or the final end-use customers in the opposite case of bundling.

Despite a relatively limited hold-up risk, the case of electric power distribution is more complicated than many transactions in other industries. Its historic regulation as a transaction occurring within a vertically-integrated, government-granted monopoly means that our starting point is one in which the wires transportation transaction is already bundled with the sale of the energy commodity transported on the wires. This bundle comprises two potentially separable transactions: one for a transportation service, whose duplication is costly, and another for a good that can be (and often is, under other regulatory institutions in other countries) sold in markets through competing retailers. The poor performance of regulation of these bundled transactions in the face of dynamic change, both economic and technological, has led to over a decade of institutional and economic change in the United States. Network industries are increasingly unbundling as technologies, other industries, and customer preferences change. For example, in electric power both the generation and the retail marketing portions of the value chain have become workably competitive, while the physical transmission and distribution wires and network operation and coordination retain some natural monopoly characteristics. The regulated, vertically-integrated firm is disintegrating under these technological and economic pressures; the main concern is how to introduce competition, or mechanisms that approximate market institutions, while making sure that the benefits of network externalities and cost subadditivity are not lost. Another concern is the kind of regulatory and institutional structure that would work well for industries characterized by networks.

In the face of these concerns, we propose thinking differently about the problems of monopoly pricing and investment in such a highly-meshed network. We explore ownership structure as an alternative to traditional regulation of government-granted monopoly ownership. In particular, we consider a competitive joint venture (CJV) ownership structure, in which competing retailers are joint owners of the wires network. Their ownership shares are determined by their market shares in the retail electricity market, and their ownership shares buy them voting rights in decisions concerning wires access pricing and management decision-making over the existing assets. Furthermore, the competitive nature of the joint venture means that existing JV members cannot block either expansion or entry; if a coalition of JV members chooses to invest in capacity expansion, or an entrant chooses to build new capacity, the existing members cannot erect entry barriers to preclude such investment. Under a contestability model of entry, such an ownership structure should lead to optimal access pricing and capacity expansion/investment.

This alternative is a hybrid between market institutions facilitating inter-firm contracts and hierarchical governance structures disciplining intra-firm transactions. Competitive joint venture (CJV) wires ownership combines "single-firm", or in this context network-internalizing, production and operations with competition at other vertical stages in the supply chain. The existence of scale economies and subadditivity of costs does not necessitate a single owner of the network; we exploit that feature to explore outcomes when competing retailers are shareholder-owners of the wires CJV.

Why explore a CJV ownership structure? Natural monopoly regulation presumes sole ownership of infrastructure assets with economies of scale and asset specificity, but that sole ownership is not necessary. The JV structure shifts the focus of analysis to questions of ownership rights and use rights that undergird the presence (or absence) of investment incentives, and away from questions of incremental improvements to information-constrained regulatory institutions. Furthermore, by making retailers both owners of wires and buyers of wires services, it harnesses the beneficial tension between buyers and sellers, which one the reason behind our theoretical result that the CJV leads to efficient access pricing. The other reason we see that result is the competitive nature of the structure – the inability to erect entry barriers reduces the ability of incumbent owners to cartelize the JV and raise access prices.

We conceptualize the competitive joint venture in a manner similar to Gale's (1994) "cost center" cotenancy. However, while in Gale production is overseen by an independent manager, implying a sort of separation between ownership and control, in the current paper ownership and control are in the hands of the shareholders, with two distinctive features:

- ownership rights in the network result from the market share each firm has on the downstream end-use customer market;
- control is exerted according to a pre-determined institutional mechanism.

We argue that the CJV ownership structure presents efficiency benefits, both static and dynamic, relative to natural monopoly regulation. In the simplest case of our model this institution performs as well as a Demsetz auction; we then extend the model to allow for investment, and we find that in that case the CJV institution outperforms the Demsetz auction, and canachieve dynamic efficiency in a full-information environment. The CJV also provides a venue for dispute resolution among the wires owners, similar to that discussed in Sampson (2004) for research equity joint ventures, and in Williamson's (1983) invocation of hostages to create credible commitment. This means of contract enforcement may be less costly than the continued regulation of the bundled wires and energy transactions. Thus we conceptualize the CJV as a multilateral governance structure in which particular transactions occur, which incorporates the mutual reliance of the members (Williamson 1983, p. 528). Such a governance structure is likely to be more robust to costly and incomplete contracting and to unforeseen contingencies.

In Section 2 we briefly summarize the industrial organization and regulation of the electric power industry. We then describe the CJV ownership structure and couch it in the context of the existing relevant literature. In Section 3 we then present a model of how competition in the retail market can be used to achieve competitive prices and efficient short term investments in the upstream distribution service market. The regulator merely enforces rules governing CJV ownership of the distribution company. Every period, the wires company is owned by the competing retailers in proportion to their market shares. As an interesting policy implication, under the aforementioned circumstances, the mechanism leads to efficiency, a property that can be particularly desirable for countries that have not completed their process of opening the electricity distribution sector to competition. In Section 4 we explore the investment incentives of this institutional structure. Section 5 concludes.

# 2 Motivation and background

Consider a competitive joint venture (CJV) structure in which competing retailers own shares in the existing capacity of the distribution network. Each member's ownership share is determined by the distribution of markets shares among the retailers in the downstream market.

With regard to capacity expansion, any member or group of members can expand capacity; the capacity use rights would belong to those members who funded the capacity expansion and would not be shared among all CJV participants. Furthermore, the CJV members cannot block an outsider from expanding network capacity (and thereby becoming a member of the CJV). Thus existing members cannot erect entry or expansion barriers. Network operations and management are shared by the CJV members.

Our analysis of the CJV as a regulatory institution for electric power distribution draws on several existing literatures. It is also informed by the use of CJV structures in other industries with high fixed-cost infrastructure, such as oil and natural gas pipelines.

## 2.1 The electricity industry and its regulation: overview

The electricity industry has a network structure consisting of four vertically integrated electricity supply functions: generation, transmission, distribution and retail. Electricity transmission and distribution are currently characterized by natural monopoly cost conditions, but electricity generation and retail are not.[3] Regulatory reforms have focused on unbundling retail prices into separate generation, transmission, distribution and retailing cost charges as well as allowing retail consumers to choose among a large number of competing generation service suppliers.

[3] Technological change in generation, particularly distributed generation, is making transmission and distribution increasingly contestable. For the purpose of this analysis, though, we assume that distributed generation implementation has not yet made centralized transmission and distribution fully contestable.

Electricity generation involves the creation of electric energy using water, fossil fuels, nuclear fuel or other energy sources. Transmission involves facilitating the high-voltage transmission of electricity between generation sites and distribution centers. In the current organizational structure, distribution involves not just distribution services but also some (or all) retailing functions, in addition to the physical delivery of the energy commodity to end-use customers.

Electricity in the United States is supplied to consumers by investor-owned or publicly-owned utilities that have exclusive franchises to sell electricity to retail customers in specific geographic areas, with investor-owned segments accounting for 75 percent of US retail electricity sales. Retail customers typically purchase electricty from a regulated monopoly supplier that has the legal right to distribute electricity to them. The regulated monopoly had the legal obligation to supply electricity within their franchise areas at prices approved by state regulatory commissions.

The U.S. electricity transmission grid is composed of three large synchronized aleternating current networks with 150 separate control areas superimposed on the three networks, where vertically integrated utilities or groups operate through power pooling arrangements. There are also organized regional wholesale markets through which utilities buy and sell electricity among one another to reduce costs of supplying electricity to customers. These transactions are regulated by the Federal Energy Regulatory Commission (FERC).

Historically, rate-of-return regulation based on natural monopoly theory has been the policy approach to what we now refer to as network industries. Two major problems are associated with natural monopoly theory. The first is that first-best price regulation requires that the regulator know the cost function, which is typically an unrealistic and infeasible requirement. The regulator knows the expenditure of the firm, which needs not be identical to the cost function, even for the observed levels of output, due to regulation-induced incentives differing from cost minimization. Hence, it is reasonable to claim that the regulator does not possess knowledge of the cost structure comparable to the firm's, and the asymmetric information reduces efficiency, inducing at most a second-best outcome from regulation. Second, price regulation can distort investment incentives, since sufficient gains (in terms of value of the product or of costs) cannot be appropriated by the firm that would be subject to price regulation once investment is implemented. A related problem arises in that the benefits of investment are very hard for the regulator to capture on behalf of customers, and investment costs are difficult to detect. Hence, except for very special cases, regulation of investment is extremely imperfect, and therefore not easily implementable.

Dissatisfaction with the results of regulation, in combination with technological change in generation, has led to movement away from rate-of-return regulation. Structural and regulatory reform in the electricity industry has followed the same basic model as that used in other network industries such as natural gas. This process involves first separating structurally or functionally the natural monopoly activities from potentially competitive ones, then deregulating prices in competitive activities so that consumers may be able to choose among competing suppliers. Natural monopoly activities are unbundled from supply of competitive activities and there is nondiscriminatory access to essential network facilities with prices determined by new regulation mechanisms that are designed to control costs better than traditional rate of return regulation procedures (Joskow, 1997). Institutional reforms to improve the performance of the industry are more complex. The main issue involved in any such effort is how to expand decentralized competition in generation and in retail such that the operating and investment efficiencies associated with vertical and horizontal integration are preserved while the costs of the regulated monopoly are reduced. The electricity industry in the US even prior to reforms was supplying electricity with high levels of reliability, investment in new capacity kept up with the growth in demand, system losses were low and electricty was provided universally. Restructuring of the electricity sector is unlikely to lead to short run cost savings. However, medium term efficiency gains may be obtained due to improvements in the operating performance of the existing stock of generating facilities as well as improvements in labor productivity. Significant long-run investments in generating capacity, or equivalent demand reduction capacity, may result from restructuring. These considerations have given impetus for restructuring and regulatory reforms in the electricity sector, particularly in states with that have experienced above-average retail rates over the past two decades.

The Public Utilities Regulatory Policy Act of 1978 was instrumental in improving competition in electricity generation. Competition and entry of new firms was further bolstered by the Energy Policy Act of 1992, which granted FERC the authority to order vertically integrated utilities to transmit power for others over regional transmission lines. The Act also left deregulation of retail electricity sales to state discretion. Some states have pursued more aggressive deregulation as compared to others resulting in price differences among regional utilities (see White et al, 1996). The gap in prices is due to the difference in price of electricity provided by the vertically integrated natural monopoly and the unbundled price of generation services which may be obtained in the wholesale market.

The main issue in the regulation of the electricity industry has been to expand decentralized competition in the generation sector while at the same time trying to maintain the operating and investment efficiencies associated with integration. Exactly how to achieve this objective is the subject of debate; for instance there is consensus that there should be a single operator controlling the physical operation of the control area but less agreement on the function of the system operator, the information required by the system operator, the ownership structure and the regulation of the system operator.

## 2.2 Literature review

Three streams of literature are relevant for the paper. The first literature addresses cotenancy arrangements specifically; relevant works address theory, law, and experimental testing of the use of cotenancy institutions. The traditional optimal regulation literature analyzes how regulators should exploit the instruments in their hands - both in terms of information and in terms of extent of their power - in order to maximize total welfare. Finally, the new institutional economics/economics of organization literature touches on several of the themes we explore here, including property rights and ownership structure, the combined use of markets and hierarchy, and the legal structure of CJVs.

Gale (1994) considers a noncooperative joint venture of firms that associate in order to exploit the economies of scale of joint production, and the possibility of using unexploited capacity of their CJV partners. Gale finds that, under a use-or-lose clause, the CJV mechanism leads to efficiency because the use-or-lose clause induces cost revelation. His argument, common to all of the papers described here, is that the CJV exploits the economies of scale of joint production, but each firm involved in it is independent, and independently sets the price. In Gale's model the operations and management of the CJV rest in an independent entity established by the CJV partners.

Alger and Toman (1990) model the creation of new markets to regulate natural gas pipelines. The structure they propose involved establishing a resale market for capacity use rights, which they argue would increase the efficiency of existing capacity allocation as well as the dynamic efficiency of capacity expansion. They report the results of experiments performed to test different designs of such a capacity market; the results suggest that a computer-aided "smart market" that integrates pipeline owner pricing decisions, natural gas purchaser bids, and natural gas producer offers. A computer algorithm that maps onto the physical network uses all of that information to calculate all prices. In their conclusion, they suggest that "where markets are neither workably competitive nor capable of becoming so just by relaxing regulatory entry barriers, another option the FERC might pursue is to encourage the development of competitive joint ventures (CJVs)." (p. 276)

Rassenti, Reynolds and Smith (1994) subsequently tested this CJV proposal experimentally for a natural gas network. Their results indicate that a computer coordinated auction market mechanism can work to allocate resources with high efficiency in a network of commodity flows. Reliance on a computer algorithm implementation of a uniform price double auction to perform the centralized coordination and dispatch of flows enables the network to retain the benefits (and, in the case of electric power, the physical necessity) of central coordination while combining it with the competitive benefits of decentralized ownership. The natural gas network that they test enables several independent natural gas commodity retailers to exercise use rights to transport natural gas over a single pipeline network. By examining an integrated market for pipeline use rights, this research expands on the results described in Alger and Toman (1990), in which an integrated "smart market" outperformed other market institutions. The market institution tested here, a continuous real-time uniform double auction, provides transparent price information for both gas and transportation at each node in the network to all participants; not surprisingly, such an institution leads to rapid price convergence and robust trading to capture the internodal arbitrage opportunities. The treatment variable was the cotenancy of use rights on the pipeline network (vs. a monopoly network link); an important feature of cotenancy in this analysis was the ability of agents to sell or lease their use rights to other agents without their fellow cotenants blocking the transaction. In these experiments the cotenancy ownership structure increased overall efficiency, reduced pipeline prices paid by buyers, and increased prices received by natural gas sellers. Cotenancy ownership of the parts of the network that would otherwise be monopoly links reduced the expression of market power in the pricing of those links, which is the primary reason for the increase in overall efficiency.

The literature on optimal regulation falls into two categories. Bayesian regulation models view the regulator as a Bayesian statistician having prior knowledge about cost and demand functions, expressed by a probability distribution. The regulator then designs a reimbursement scheme that maximizes total (or consumer) welfare under the constraint of decentralized information. The main papers in this stream of literature (Laffont and Tirole (1990), Baron and Myerson (1979), and Sappington (1983)), find optimal incentive mechanisms that, while minimizing the informational rent left to the monopolists, in general cannot attain the first best level of welfare that could be achieved under perfect information. Furthermore, Koray and Saglam (2005) suggest that the Bayesian regulator will itself require oversight because his bleiefs may be manipulable, and such manipulation may not be detected because the regulator's beliefs are not common knowledge.

Non-Bayesian regulation models (the second category) do not impose informational requirements on the regulator. Institutional mechanisms in non-Bayesian models work regardless of how much the regulator knows about the firm's cost and demand structure.

In that tradition, Demsetz (1968) proves that first best static efficiency (i.e., pricing), can be achieved by auctioning the monopoly franchise rights, and allocating the right to manage the monopoly to the firm offering to sell the product at the lowest price. Despite its efficiency properties, two issues arise with Demsetz's auction. First of all, having enough firms taking part in the auction to ensure the prevalence of the competitive outcome is important but not assured.[4] Second, Demsetz's auction achieves static efficiency, but it does not perform well in terms of dynamic efficiency. Indeed, given that the regulator, in the absence of information, is unable to measure quality, and given that the firm performing an investment will not necessarily enjoy its full future benefit (it can be replaced by one of the competitors in future auctions), there is a tendency towards underinvestment both in

[4] A firm's participation in the auction is obviously not guaranteed.

quality-enhancing, and in cost-reducing activities. The static efficiency achieved in a Demsetz auction forms one of the benchmarks against which we will evaluate the performance of the CJV as a regulatory institution.[5]

Loeb and Magat (1979) illustrate, within a non-Bayesian framework, a mechanism in which the regulator awards the monopolist a lump-sum subsidy covering the whole consumer surplus; they prove the mechanism achieves maximum total surplus when demand is known to the regulator, but the cost function is not. However, this institutional arrangement assumes, unrealistically, that public funds have no cost. Finally, Vogelsang and Finsinger (1979) propose a dynamic adjustment mechanism that converges in the long run to efficiency, assuming firms react myopically, maximizing the short-run profit every period.

The new institutional economics literature contributes a different dimension to analyses of traditional regulation and organizational alternatives to it. The NIE approach models the firm as more than a frictionless center of production and of transformation of inputs into outputs, with transactions costs both within the firm and the market shaping the optimal firm size and boundaries. The CJV structure analyzed here leverages the vertical nature of the electricity supply chain and the fact that some sectors within that supply chain can be competitive. In this sense the CJV is a contractual alternative to vertical integration in much the way that Klein, Crawford and Alchian (1978) described in their analysis of the organizational substitutability of vertical integration and long-term contracting. Later work by Grossman and Hart (1985) and Hart and Moore (1998) elaborate on the tradeoff between vertical integration and contracting outside the firm and the effect of ownership on incentives.

The electric power network is not only part of a vertical supply chain; it is also a network comprising transaction-specific and site-specific assets. Holdup problems in vertical supply chains in the presence of asset specificity were another focus in Klein, Crawford and Alchian (1978), as well as Williamson (1975). The potential for a single infrastructure owner to hold up producers in the downstream industry in the chain is a salient one in electric power, both because of subadditive costs in the wires segment and because of asset specificity. We explore the extent to which a CJV structure can overcome such holdup problems and opportunism while retaining the cost benefits of the network infrastructure.

Sampson (2004) explores the benefits of internal organization for controlling opportunism in a research equity joint venture context. Placing the joint venture in the continuum of governance institutions between market processes and hierarchy, she finds that the internal organization of a joint venture ownership structure can control opportunism and free riding through the use of both rules and information flow. Having a joint venture management board comprising representatives of all members facilitates monitoring, which

[5] See also Williamson (1976) for a seminal related analysis.

reduces opportunism. It also provides an alternate dispute resolution venue, and one that may be less costly than courst given the reality of contract incompleteness. Sampson also finds that joint ventures enable members to respond to unanticipated conditions in ways that would not be possible if they were not acting in concert. Finally, she argues that the joint venture structure reduces transactions costs relative to a bilateral contract market mechanism, because the participants do not have to write as fully contingent a contract as they would in that case.

A related issue in applying these concepts in a network industry is access to the network. Carlton and Salop (1996) analyze the extent to which, and the conditions under which, network joint venture participants can exclude others from participating in the joint venture. With a network joint venture that provides an input that competing members use to produce output, members have an incentive to implement exclusionary rules to restrict access. Building on the earlier work of Carlton and Klamer (1983), Carlton and Salop argue that in some cases such exclusion can have beneficial efficiency consequences, while in others the exclusion is anti-competitive. Their joint venture model starts with an analysis of the negative and positive externalities that occur in networks; members have an incentive to free ride on the assets provided by other participants (as also seen in Sampson 2004), but each individual member cannot capture all of the surplus created through exclusionary access policies and the consequent possible output restriction. Within this context they analyze the efficiency tradeoff in exclusionary access rules. Limiting membership (and hence access) can have both static and dynamic efficiency benefits through increased coordination to reduce the transactions costs that are common in interfirm coordination issues. Also, reduced free riding on the assets of other members can lead to optimal dynamic investment incentives. The costs of such limitation, though, can be reduced downstream competition because the joint venture can facilitate price coordination; participants may also have more opportunities to raise rivals' costs. These access issues pose a fundamental challenge in determining the governance structure of a joint venture, particularly because the interplay of these opposing effects will differ from case to case. In such a context, and if a joint venture ownership structure is to provide a beneficial alternative to natural monopoly regulation, institutions matter a great deal.

Within the intersection of the property rights and NIE literatures, Eggertson (2003) analyzes the differences between open access, common ownership, and corporate ownership. Open access implies that all people within the community have the right to use the good. Nobody can, however, exclude others from enjoying the good, nor can anybody alienate its rights to use the good. Management is either absent, in some forms of open access such as fields of a mountain, or exerted by the State. Common ownership, on the other hand, is a form of joint ownership between a group of insiders. Outsiders are excluded from enjoying the good. Bargaining for the right to manage has to be specified among insiders. With respect to corporate ownership, it displays the significant difference of inalienability of property rights. If we think of the CJV structure within Eggerston's context, it can be classified as a form of common ownership without a specified property right structure, with the consequence of not being able to specify who is managing the CJV or how incentives work. This line of research stems from Ostrom's (1990) seminal theoretical and field work on the use of governance institutions to avoid rent dissipation in situations with common ownership.

### 2.3 The use of CJVs in other industries

CJV ownership as a regulatory institution has been advocated by economists in a variety of models. Alger (1998) argues for using open ownership and competitive rules as opposed to Common Carriage for the New Zealand Natural Gas Pipeline Industry; this model involves open ownership so that anyone may purchase long term rights to capacity at prices within regulatory constraints, owners must have undivided common interest in shared facilities and it may be possible for owners to establish a total owned capacity which is artificially below physical capacity. Competitive rules would involve owners independently marketing services while paying regulated prices that just cover variable cost, a use it or lose it rule regarding available capacity and establishment of an operator who is independent of any user and who is charged to act neutrally with respect to all owners. These are the rules that may be applied generally for industries exhibiting networks where some activities are competitive and others natural monopolies; therefore they apply to the following industries (electricity, telecommunications, airlines, railways) as much as they apply to natural gas industries.

Doane and Spulber (1994) look at the effects of open access transportation on the organizational structure of natural gas in 1980s. They find that open access integrated regional wellhead markets into a national competitive market for natural gas. They also find that incentives for long term contracts between pipelines and producers are removed by introducing open access competitive buying and selling of gas at the wellhead.

Other industries in which CJV ownership is used to structure transactions include pharmaceutical research and development, computer memory chip production, and oil pipelines. In these industries CJVs serve to decrease costs while retaining economies of scale, using contracts to define use rights and to govern the sharing of benefits and of maintenance costs and investment.

## 3 A CJV model of electric distribution

With this model we propose and analyze the properties of a CJV possessing two important institutions: rules governing ownership structure, and rules governing the determination of the price of wires access. This framework thus suggests a regulatory institution that employs two instruments that are not standard in the mainstream regulation literature: the ownership structure of the CJV wires firm, and the decision-making procedure governing the firm. After setting the "rules of the game," the regulator does not intervene further, and the CJV partners face the task of autonomously establishing prices, quantity and the level of investment. We first present a model in which firms choose output prices and quantities, and we then extend the model to incorporate the investment choice.

### 3.1 The regulatory mechanism: CJV ownership rules

The model stylizes the market for the distribution of electricity. Electricity distribution displays very complex features, well summarized, among others, by Wilson (2002). The present model displays a set of simplifying assumptions, some of which will be relaxed in the following sections.

Consider a simple retail electricity market served by N firms selling a homogeneous product. These N firms possess ownership and use rights in the (single) distribution wires infrastructure, determined by their retail market share. Our model further assumes a credible regulatory environment in which ownership rights, use rights, and the governance and price determination mechanisms in the CJV are enforceable. This institutional enviroment is known to both the CJV partner firms and the end-use retail customers, who choose accordingly.

We first assume that firms have unlimited liability, in the sense that they charge consumers the access prices they commit to before they know the wires access charge, regardless of whether this access price is actually ultimately implemented by the distribution company. In other words, we are allowing for the possibility that firms make a negative profit.

At the beginning of each period $t$, each firm $i$ commits to a price $p^i$, the price for the retail service that the firm is going to charge the customers. The price $p^i$ is the price that each consumer pays to firm $i$ during period $t$ for each unit of electricity she is consuming, if she chooses to be supplied by firm $i$.[6] This rule ties the retailer's choice of retail price and the incentive to gain market share to their ability to choose the upstream access price.

Consumers choose among the $N$ firms in order to maximize their utility. We assume that each consumer's utility is quasilinear in the electricity service, and it is given by:

$$U_i\left(E\right) = v_i\left(x\right) + y$$

[6]For practical considerations, the length of period $t$ should be chosen appropriately: not too short, in order to avoid the emergence of excessive transaction costs for customers, due to the the high informational load, but not too long, either, in order to give firms and customers the ability to adapt in a dynamic market.

where $x$ represents the amount of electricity that is being consumed, and good $y$ is the numeraire.

Assume there are two types of customers, differentiated by their demand. Namely, there are $L$ residential customers, and $M$ industrial customers. Denote the individual demand function for each industrial customer $x_i^{ind}(p)$, while the demand function of each residential customer is denoted as $x_i^{res}(p)$. The inverse demands are denoted respectively $P_i^{ind}(x)$ and $P_i^{res}(x)$. The aggregate demand function is $P(x)$, with $P_x \leq 0$.

Denote $x^*$ the quantity that maximizes total surplus, i.e, the quantity produced if retailers have a null profit. Note that by the envelope theorem, $\frac{\partial P}{\partial x*} = 0$ for a given $q$. The reserve price is the same for both types of customers. However, for any $p\epsilon[0, p(0)]$, $x_i^{ind}(p) > x_i^{res}(p)$; thus industrial demand is larger than residential demand at all relevant prices. This characteristic reflects the fact that industrial customers tend to consume more than their residential counterparts, but at the same time they have a similar pattern of substitution towards alternative energy sources as relative electricity prices increase. A justification for assuming the same switching point to alternative energy sources is provided by the fact that both types of customers face the same input prices. Aggregate demand for industrial customers is denoted as $x^{ind}(p,q) = Mx_i^{ind}(p,q)$, while for residential customers it is $x^{res}(p,q) = Lx_i^{res}(p,q)$, and for the two groups together it is given by $Mx_i^{ind}(p,q) + Lx_i^{res}(p,q) = x(p,q)$. Inverse demands are respectively $P^{ind}(x,q)$, $P^{res}(x,q)$and $P(x,q)$.

The cost of the wires service is $C_w(x)$. The cost structure is such that $\frac{\partial C}{\partial x} > 0$, $\frac{\partial C}{\partial x^2} \leq 0$. The cost function of a retail company is composed of the cost of the wires distribution service, and of the input cost, given by the wholesale cost of the electricity commodity. We assume that wholesale price is taken parametrically by the firms, so there is no room for bargaining on the wholesale electricity price.

Consumers' choices determine the split of the market, the retail market share, among the $i$ firms. The market share determines the share of "ownership" in the wires CJV. An ownership share in the CJV means that the firm owns a share of the common wires infrastructure, and that share is proportional to the downstream retail market share. A firm's ownership share determines its ability to choose the wires access charge that it and the other retailers will pay. It does not, though, allow any firm to block entry of new firms to the CJV, or to prevent expansion via the construction of new wires.

The retailer with the highest ownership share sets an access charge, under only the condition that it has to be uniform across all retailers. The wires CJV cannot price discriminate across its member retailers. Each firm has to pay the access charge $a$ to the distribution company for all units of electricity sold. Under the simplifying assumption of zero cost for the retail activity, the retailer's profit resulting from the retail activity is defined as:

$$\pi_r^i = p^i x^i - a x^i$$

That is, the unit price charged to customers multiplied by the quantity sold to them net of the access charge that retailers are being charged by the wires company.

Notice that the retailers' profits are composed of profit resulting from the retail activity and profit resulting from the ownership share in the wires company. Total profit in the wires company is given by:

$$\pi_w = ax - C_w(x)$$

It follows that total profit for firm $i$ under this market design is given by:

$$\pi^i = \pi_r^i + \frac{x^i}{x}\pi_d = p^i x^i - a x^i + \frac{x_i}{x}\left(ax - C_w(x)\right)$$

Notice that we are assuming that firms have unlimited liability, in the sense that the timing of the game prescribes that the price retailers charge to consumers is fixed prior to the access charge that the wires company charges the retailer, and it is not affected by it.[7]

The timing of the model is thus as follows:

1) firms credibly commit to a price $p_i$ they will charge customers in period $t$.
2) $a$ is determined
3) Production occurs
4) Profits are determined

The retailer is now thus both a customer and a shareholder in the wires company because of its CJV ownership structure. This situation creates a potentially beneficial conflict of interests. On one hand, the firm would like the access price as low as possible as a wires service purchaser; on the other hand, as an owner, the firm prefers an high access price to gain more profit. Furthermore, the ownership share of the wires company is determined by the market share in the retail sector. The retailer is driven to lower its cost not only, as usual, to increase his share in the retail market, but also in order to increase his ownershisp stake in the wires company. Thus we have three driving forces of the prices beyond the standard ones. The retailer has an incentive to lower prices in order to gain a larger share in the distribution company. Also, she has an incentive to lower the access charges in her role of client of the distribution company. On the other hand, in her role of owner of the distribution company, she has an interest to increase the prices, in order to increase her profits. Furthermore, all $N$ retailers face these complex incentives,

[7] In principle, this situation could give rise to negative profit for the retailer The question of how uncertainty over the access charge affects the price a retailer chooses is the subject of further research.

and interact both as competitors and as CJV partners. All $N$ retailers also face potential entry, and can choose to expand capacity. If that contestability effect is strong, it can undermine the ability of the $N$ CJV partners to act as a cartel.

In this institutional structure the regulator has three major tasks. It enforces the ownership structure of the distribution company. It guarantees the mechanism for defining the wires access charge. Finally, it guarantees that the prices the retailers commit to with the customers are indeed implemented. These tasks require the regulator to have less private and less *ex ante* information about firms' costs than the traditional natural monopoly regulation approach; thus this approach circumvents many of the problems that the Bayesian regulator literature addresses.

In this setup, the regulator's task consists of guaranteeing the institution. Unlike standard methods of regulation, there is no active role for the regulator in this institution.

### 3.2 The wires pricing decision

We begin by showing that retailers' profit does not depend on the access price charged by the wire company.

**Proposition 1** *Retailers' profit is independent of the access price a charged by the wire company*

**Proof.** Using the previous computations, retailers' profit is given by:

$$\pi^i = \pi_r^i + \frac{x_i}{x}\pi_w^i = p^i x^i - ax^i + \frac{x_i}{x}\left(ax - c_w\left(x\right)\right)$$

Simplifying, we have:

$$\pi^i = p^i x^i - ax^i + ax^i - \frac{C_w\left(x\right)}{x} = p^i q^i - \frac{C_w\left(x\right)}{x}$$

which does not depend on $a$. ■

The intuition for the result is quite transparent. In its role of customer of the wire company, the retailer regards the access charge as a cost; hence its profit due to the access charge is $-ax^i$. In its role of owner of the wire company in proportion to its market share, the firm gets back exactly the same amount, $ax^i$. This result, which depends on the decision-making institutions of the CJV, is crucial for the analysis.

Now, it is possible to solve for the Nash equilibrium of the game. The game is played in two stages. In the first one, firms credibly commit to the announcement of a price. In the second, each consumer independently chooses her own retailer.

**Proposition 2** *In all the Nash equilibria: i)the price charged by the wire company equals the average cost ($p^* = \frac{C_w(x)}{x}$); ii) the market produces the surplus-maximizing quantity $x^* = x(p^*)$. Efficiency is achieved.*

**Proof.** Suppose by contradiction that $p^i > \frac{C_w(x)}{x}$. Then, a firm $i'$ would find it profitable to lower prices to $\frac{C_w(x)}{x} < p^{i'} < p^i$. It would serve the whole market and it would still gain positive profit. Suppose on the other hand that $p^i < \frac{C_w(x)}{x}$. Then, $i^*$ is losing money, so it has an incentive to shut down. On the other hand, if $p^i = \frac{C_w(x)}{x}$, no firm $i'$ has an incentive to offer $p^{i'} < p^i$, as it would lose money; if indeed $i'$ offers $p^{i'} > p^i$, it would serve no market.

It follows that the equilibrium output, $x^* = x(p^*)$. Hence social surplus is maximized. ■

Having assumed constant or increasing return to scale for the wires service, average cost pricing maximizes welfare subject to uniform pricing and a break-even constraint. Consumers in equilibrium pay exactly the sum of the marginal costs of the retail and of the distribution sector. The monopoly distortion vanishes in the aftermath of the application of this mechanism, and (first-best) efficiency is achieved.

Even Demsetz's procurement auction, previously discussed, possesses similar properties, and yields static efficiency. As we will see later, however, our CJV mechanism has more desirable features than a Demsetz auction in a dynamic setting.

This model possesses several similarities to the open ownership model, as established by Gale. Indeed, here the only role of the CJV firm is setting an access price. It does not have to purchase inputs, nor bear maintenance costs, or investment costs of any kind.[8] Given the allocation rule for the profit, that it is distributed proportionally among shareholders based on downstream market share, this model and the open ownership model do not differ substantially from each other. However, the institutional mechanism that regulates the two is different. In the traditional form of cotenancy, such as the one Gale analyzes, all parties buy the right to access the wires, and the firm is managed by an independent manager, whose incentives are left unspecified. In the present setting the firm is managed by a manager who is constrained in his decisions by the preset variables set up in the assembly of shareholders. Gale's model does not attempt to find an incentive-compatible mechanism inspiring the manager's actions. Indeed, in Gale it is unclear why the manager would behave in a way consistent with the firm's profit maximization. Our paper specifies

[8] Clearly, a real-world CJV implementation would be likely to involve both maintenance and investment functions.

an institution that drives the agents' actions, and allows them to achieve the desired outcome in an incentive-compatible manner.

The current model can be regarded as an auction implicitly run at the retail stage for the single-period ownership of the distribution company. It is a form of rent of the company (the renters have no right to sell their ownership share in the CJV, and they have to give it up at the end of the period), whose price results from the auction at the retail stage. The incentive towards static efficiency in terms of pricing is guaranteed by this auction procedure, namely by the fact that, given the ownership structure, transfering revenue between the distribution and the retail activity is a neutral operation. The involvement of retailers in the upstream distribution stage may decrease the incentives for sabotage (see Beard, Kaserman and Mayo 2001), and in any event is likely to increase the control of the stakeholders on the company.

The CJV places no demand on public funds. With respect to the other papers in the non-Bayesian literature, in which efficiency is achieved only through a lump-sum subsidy awarded by the regulator, the institutional arrangement presented here does not require (costly) public funds.

# 4 New investment

The previous section focused on a mechanism to achieve static (pricing) efficiency. We now extend the model to analyze a mechanism to achieve a desirable investment level, and, as a consequence, dynamic efficiency. The mechanism is based on the creation of a market for the right to connect to the grid, with a firm acting as a market-maker, given the CJV structure in which existing owners cannot block entry or expansion of the network. The market for connection to the grid is a market for use rights over the available wires capacity. In conjunction with the CJV ownership rules, the market for grid use rights solves the free riding problem arising if connection to the wires is a public good. Furthermore the presence of a firm acting as a market-maker solves the externality between customers in collectively choosing the level of investment.

We first examine an environment in which new customers have to be reached by the wires, due, for example, to the development of a new urban area. Assume that there are $i$ potential new industrial customers, and $j$ potential new residential customers. Wires construction has a fixed cost $F$ that does not depend on the number of customers that are using it. The intuition behind this assumption is that laying the line has a cost that is independent of the number of users. This simplifying assumption does not change the nature of our results.

This market design induces an efficient investment level. The mechanism is based on three stages:

First, the right to build extra wires is auctioned off. Both existing retailers and other firms are eligible to construct new capacity, in keeping with the lack of entry barriers in the CJV structure. If multiple firms take part in the auction, each firm bids an amount $R > 0$ which the firm is willing to pay for the right to build an additional unit of wires capacity. The firm bidding the highest $R$ obtains the right to build the wires. The amount $R$ is then redistributed across customers according to a redistribution rule which is left unspecified here.[9]

The right to build the new wires carries with it use rights over the additional capacity. Excludability is a key property allowing us to obtain the desired results, and excludability arises from the use rights accruing to the firm that invests in the capacity expansion. Our general framework allows for contracts in which the retailers own those rights to be connected to the grid on behalf of their end-use customers, and contracts in which the end-use customers themselves own those rights. Requiring customers to affirm those rights (or retailers to do so on their behalf) is the mechanism through which the CJV can make use of the wires capacity excludable.

Second, the use right in the new capacity is alienable; the firm can either keep it or sell it. Hence, the CJV is entitled to distribute electricity only on behalf of those retailers that own the right to connect to the grid, or to those customers that own the right to connect to the grid. Secondary trade of the right to connect to the grid is allowed. Hence, each potential new customer can buy the right to connect to the grid either directly from the construction, or from previous customers who are selling their right, or from intermediaries.

Third, consumers who own use rights are supplied by the retailers.

Because the grid use right is a clearly-defined property right, the firm that builds additional capacity essentially provides a discipline device. If that firm owns the use right in the additional network capacity, it solves the latent externality involved in the investment problem.

Denote respectively as $W_{ind}$ and $W_{res}$.the surpluses generated for the two types of customers (industrial and residential). We now prove that this mechanism generates an optimal investment level under the assumption of full information. While perfect information is a simplifying assumption, it is an extension of the argument that a firm, directly

[9]Think of this stage as a simplified implementation of the CJV's rule against entry barriers. While without loss of generality we refer to a single firm making an investment, a consortium of firms could also do so.

involved in the market, is able to compute surplus in a much more accurate way than a regulator or a central planner.

**Proposition 3** *When investment in additional capacity to reach new customers is performed by a firm that has alienable network use rights and can exclude potential customers from using the wires, investment is efficient.*

**Proof.** Assume that there are firms participating in the auction. The winning construction company sells the right to connect to the grid at the reservation value for each customer. Under the possibility of perfect price discrimination (a very natural assumption in this context), the company will extract from each type of customers (almost) the full value of its expected future surplus, $W$ ($W_{ind}$ for the industrial customers, and $W_{res}$ for the residential customers). All customers will then buy the right of being connected to the CJV system, as the surplus that interconnection generates for them is weakly higher than the price they have to pay for interconnection. The profit for the construction firm, in case it builds the line, is:

$$\pi = jW_{res} + iW_{ind} - F - R$$

Under perfect information, if the auction is competitive, then profit of the winning firm equals zero, and $R$ equals:

$$R = jW_{res} + iW_{ind} - F$$

Clearly, if $R < 0$, the firm will not build the line. But if $R < 0$, then $jW_{res} + iW_{ind} < F$, hence the overall benefit from the investment is lower than its cost. Hence, the investment is not optimal, and it is not performed in equilibrium in this case.

If $R > 0$,the overall benefit from the investment exceeds its cost. Hence, the investment is optimal, and it is performed in equilibrium in this case. ■

We now investigate an environment in which an extra investment is needed to avoid consumers rationing after a demand increase. Assume there are two time periods. In one, capacity is sufficient to supply all the electricity at the prevailing price, $k > x_1(p)$, while in the other, this is not the case, $k < x_2(p)$. In period 2, then, not all the customers will be able to be supplied for an amount that equals their demand. Denote the demand for each industrial customer in period 1 as $x_1^{ind}(p)$, where the subscript refers to the period, and the superscript to the type of consumer. Denote the demand increase for residential customers by $\Delta x^{ind}(p,q) = x_2^{ind}(p,q) - x_1^{ind}(p,q)$, and analogously the demand increase for residential customers by $\Delta x^{res}(p,q) = x_2^{res}(p,q) - x_1^{res}(p,q)$. In period 2, capacity rights are allocated. The cost function is then $C(k)$, with $C'(k) > 0$, and $\frac{\partial \frac{C(k)}{c}}{\partial c} < 0$ (decreasing average cost). Assume $C(k)$ may be represented by $C(k) = F + ck$.

As an analogue to the previous case, we want to prove that if an auction is run for the right to construct the wires, then the winning firm builds the wires, and can sell the use rights to the customers, then an optimal level of investment is attained.

**Proposition 4** *When a firm invests in additional capacity to react to an increase in electricity demand, when that firm is selected through an auction procedure, and when a market for network use rights is in place, then investment is efficient.*

**Proof.** Whatever the allocation of transmission capacity is at time period 1, as long as capacity rights are tradable, the allocation at time period 2 is such that each single capacity unit is allocated to the customer that values it more at the margin. Otherwise, there would be a profitable trade that is not taking place, and this would not be an equilibrium. Assume there is a firm that is willing to construct the wires. The firm that has won the auction sells the right to use the capacity it has constructed, extracting the full value that this capacity generates for end-use customers, denoted as $W'(k)$ (which represents the overall surplus generated by the increase in capacity, given that the existing capacity is allocated in an efficient manner). Profit maximization entails setting capacity $k^*$ at a level such that $C'(k) = c = W'(k)$. Hence, capacity is increased until the marginal cost of capacity hits the marginal benefit of capacity (fully extracted by the construction firm). The construction firm will add capacity if:

$$R = W'(k^*) - ck^* - F > 0$$

If, on the other hand, $R = W'(k^*) - ck^* - F < 0$, the construction firm will not add capacity, a result consistent with social welfare maximization. Hence, the investment level is always set at the optimum. ■

In this case, a market for wires use rights, coupled with the presence of a firm acting as a market maker, solves the free riding problem that may potentially thwart optimal investment. This set of institutions enables dynamic efficiency, in conjunction with the CJV rules that led to static efficiency is achieved through the CJV mechanism.

## 5 Conclusion

As Vernon Smith observed almost 20 years ago, "... if the company shares the capacity of a transmission line, then it can either use it, sublet it, or sell it. If just one line with excess capacity exists, then a potential user has two or more owners with whom he or she can bargain. Consequently, competition in a market for rights can exist even where only one physical producing unit exists. Scale economies in production need not have anything to do with monopoly in ownership and control. This institution is particularly important in understanding future possibilities for deregulating transmission and distribution." (1988, p. 19)

The CJV institution analyzed here comprises two rules: an ownership rule and a wires access price determination rule. These rules exploit the beneficial tensions that arise because the agents in the CJV are both buyers and sellers, and they thus represent the derived demand for wires service from the downstream retail customers. We find that in a model implementing this CJV structure, it can achieve both static and dynamic efficiency, although the dynamic efficiency result relies on strong assumptions.

Our contribution in this paper is the proposal and analysis of a specific institution, competitive joint venture ownership of a wires network, as an alternative to natural monopoly regulation. Specifically, we apply various literatures within new institutional economics to examine the specifics of governance, incentives, and performance of a CJV institution that integrates downstream competition and upstream use and control rights. Unlike earlier work examining such an institution, we focus on the beneficial incentive alignment of the CJV within a vertical framework. The integration of the ownership rule and the price determination rule in the CJV enables us to address the type of agency problems and hold up problems analyzed in the NIE literature. Furthermore, our institution's use of a downstream market share as a form of auction provides a practical way to handle problems of contract incompleteness that would invariably arise in such a complex set of transactions.

Some of the existing works on CJVs in infrastructure have pointed out that the scale benefits of network infrastructure does not necessitate monopoly ownership (see, for example, Gale 1994, Smith 1988). This CJV institution suggests that the combination of a competitive downstream retail market and a market for use and control rights on the upstream infrastructure can generate beneficial results, without the onerous information requirements that traditional regulatory institutions impose.

We will extend this research by using this model as a framework for establishing an experimental environment to test the access pricing and investment performance of the CJV institution. We propose comparing the regulatory institution and the pricing rule embodied in this CJV setting to a traditional rate-of-return regulated setting, using the Nash equilibria predictions from the model proposed here as the benchmark for evaluating the experimental results.

Other extensions to pursue include the effect of the CJV structure on the quality decisions of the firms, the effect of incumbency on the performance of the CJV, the effect of asymmetric firm size, and the effect of firm entry and exit on the CJV's performance. We expect that such research would generate useful knowledge concerning the applicability, feasibility, and benefits of using CJV ownership as an alternative to natural monopoly regulation.

## References


[1] Alger, Dan. "Open Onwership, Not Common Carriage," working paper, New Zealand Institute for the Study of Competition and Regulation, December 1998.

[2] Alger, Dan, and Michael A. Toman, "Market-Based Regulation of Natural Gas Pipelines," Journal of Regulatory Economics, Vol 2, No. 3, 1990: 263-280.

[3] Arnold, Terence, and Lewis Evans, "The Law and Economics Basis of Enforcement of Governance of Private Joint Venture Network Markets: The Case of NZEM," New Zealand Institute for the Study of Competition and Regulation, January 2000.

[4] Baron, David P., and Roger B. Myerson, "Regulating a Monopolist With Unknown Cost," Econometrica Vol 50, 1982: 911-930.

[5] Beard, Thomas, David Kaserman, and John Mayo, "Regulation, Vertical Integration, and Sabotage," Journal of Industrial Economics, Vol. 49, 2001: 319-333.

[6] Carlton, Dennis W., and J. Mark Klamer, "The Need for Coordination Among Firms, with Special Reference to Network Industries," University of Chicago Law Review Vol 50, 1983: 446-465.

[7] Carlton, Dennis, and Steven Salop, "You Keep On Knocking But You Can't Come In: Evaluating Restrictions On Access To Input Joint Ventures," Harvard Journal of Law and Technology, Vol 9, Summer 1996: 319-.

[8] Coase, Ronald H., "The Nature of the Firm," Economica Vol 4, 1937: 386-405.

[9] Demsetz, Harold, "Why Regulate Utilities?" Journal of Law and Economics, Vol 11, April 1968: 55-66.

[10] Doane, Michael J. and Daniel F. Spulber, "Open Access and Evolution of the U.S. Spot Market for Natural Gas," Journal of Law and Economics, Vol 37, No. 2, Oct. 1994: 477-517.

[11] Gale, Ian, "Price Competition in Noncooperative Joint Ventures," International Journal of Industrial Organization Vol 12, No. 1, 1994: 53-69.

[12] Grossman, Sanford, and Oliver Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," Journal of Political Economy Vol 94, No. 4, 1986: 691-719.

[13] Harris, Robert G. and C. Jeffrey Kraft, "Meddling Through: Regulating Local Telephone Competition in the United States," Journal of Economic Perspectives, Vol 11, No. 4, Autumn 1997: 93-112.

[14] Hart, Oliver, and John Moore, "Cooperatives vs. Outside Ownership," NBER Working Paper, 1998. Available at http://www.nber.org/papers/w6421.pdf.

[15] Joskow, Paul L., "Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector," Journal of Economic Perspectives, Vol 11, No. 3, Summer 1997: 119-138.

[16] Klein, Benjamin, Robert G. Crawford, and Armen A. Alchian, "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process," Journal of Law and Economics Vol 21, No. 2, 1978: 297-326.

[17] Koray, Semih, and Ismail Saglam, "The Need for Regulating a Bayesian Regulator," Journal of Regulatory Economics, Vol 28, 2005: 5-21.

[18] Loeb, Martin, and Wesley A. Magat, "A Decentralized Method for Utility Regulation," Journal of Law and Economics, Vol 22, No. 2, 1979: 399-404.

[19] Lyon, Thomas P. and Steven C. Hackett, "Bottlenecks and Governance Structures: Open Access and Long Term Contracting in Natural Gas," Journal of Law, Economics and Organization, Vol 9, No. 2, Oct. 1993: 380-398.

[20] Mulherin, J. Harold, "Complexity in Long term Contracts:An Analysis of Natural Gas Contractual Provisions," Journal of Law, Economics and Organization, Vol 2, No. 1, Spring 1986: 105-117.

[21] Ostrom, Elinor, Governing the Commons. Cambridge: Cambridge University Press, 1990.

[22] Pacific Northwest National Laboratory, GridWise: The Benefits of a Transformed Energy System, PNNL-14396, September 2003. Available at http://www.pnl.gov/energy/eed/etd/pdfs/pnnl-14396.pdf.

[23] Rassenti, Stephen J., Stanley S. Reynolds, and Vernon L. Smith, "Cotenancy and Competition in an Experimental Auction Market for Natural Gas Pipeline Networks," Economic Theory, Vol 4, No. 1, 1994: 41-65.

[24] Sampson, Rachelle, "Organizational Choice in RD Alliances: Knowledge-Based and Transaction Cost Perspectives," Managerial and Decision Economics, Vol. 25, 2004: 421-436.

[25] Sappington, David, "Optimal Regulation of a Multiproduct Monopoly with Unknown Technological Capabilities," Bell Journal of Economics, Vol 14, No. 2, 1983: 453-463.

[26] Stigler, George, and Claire Friedland, "What Can Regulators Regulate? The Case of Electricity," Journal of Law and Economics Vol 5, 1962: 1-?.

[27] Vickers, John, "Competition and Regulation in Vertically Related Markets," Review of Economic Studies, Vol 62, No. 1, January 1995, 1-17.

[28] Williamson, Oliver E., "Credible Commitments: Using Hostages to Support Exchange," American Economic Review, Vol 73, No. 4, 1983: 519-540.

[29] Williamson, Oliver E., "Franchise Bidding for Natural Monopolies-In General and With Respect to CATV," Bell Journal of Economics, Vol 7, No. 1, 1976: 73-104.

[30] Williamson, Oliver E., Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press, 1975.

[31] Wilson, Robert, "Architecture of Power Markets," Econometrica Vol 70, No. 4, 2002: 1299-1340.