VERTICAL INTEGRATION AND THE RESTRUCTURING OF THE U.S. ELECTRICITY INDUSTRY*

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Abstract

Debates on restructuring of the U.S. electricity industry are often about the degree to which market relationships should replace transactions that formerly took place within regulated, vertically integrated utilities. Markets for the purchase of energy by vertically unintegrated distribution utilities are clearly feasible, but vertical deintegration of existing systems may entail foregoing some operational and reliability benefits that are important in light of electricity's unique characteristics. Research and policy on restructuring have almost totally disregarded a large econometric literature on the savings from vertical integration. At the same time, policymakers have accepted the results of flawed studies that purport to estimate the benefits of switching to a market regime. A review of California's restructuring history shows that vertical integration was viewed primarily as a tool that incumbent utilities might use to perpetuate their market power. The disregard of its benefits led to questionable divestitures that produced superficially competitive market structures, and to the institution of Independent System Operators whose costs have yet to be compared to their benefits.

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I. Introduction: Vertical Integration and Electricity

Almost since their origin, electric utilities have been vertically integrated, with generation, transmission, and distribution combined in a single firm. The maintenance of reliability requires a centralized organization to ensure that the supply of energy equals demand at every instant over a wide area. Low-cost production requires the simultaneous optimization of generator dispatch and allocation of transmission capacity. Long-run efficiency requires the coordination of investment decisions at all stages of the chain from generators to low-voltage distribution lines. Not all of the industry's decisions are made within vertically integrated firms. Contracts between them and outside parties govern activities that range from fuel supply procurement to power purchases from other suppliers. Utilities also rely on markets. They evaluate the offers of competing sellers when purchasing office supplies and the offers of competing buyers when disposing of a few hours' surplus power production. These market relationships are not durable: if next week a different seller announces a lower price on office supplies the utility will probably leave its previous supplier.

The past thirty years have transformed the economic theory of the business firm. The traditional topics of efficient input choice, profitable output choice, and optimal competitive strategy are now subsumed in a more general theory of economic organizations. Instead of assuming that the scope of a firm's activities is fixed, economists now treat its boundaries as matters of choice. The economics of organization asks such questions as whether the firm should purchase its raw materials in markets or produce them in a facility that it owns, and whether its product should be sold by salaried employees or by independent retailers. A rational decision on producing its own raw material versus buying it requires that the firm consider alternative ways to hedge price uncertainty and ensure deliveries, its ability to coordinate production and use of the input, and its competence in managing the dissimilar activities of raw material and output production. Vertical integration is at the heart of the economics of organization.

Economic models of competition and competitive behavior apply to both markets and organizational choice. A firm of given scope can compete by discovering a profitable market that other sellers have neglected, by introducing an innovative pricing plan or developing a new production technology.[1] In organizational economics, firms also compete by altering the mix of activities that they undertake in response to perceived changes in their environments, whether they be changes in prices, market institutions, or technology. A firm that mines its own raw material may choose to sell the mine after a commodities exchange develops contracts and financial instruments that allow it to hedge at low cost. Another may choose to abandon its relationship with wholesalers and sell directly to final customers as an Internet market develops. Organizational innovations spread through an industry if they enhance firms' abilities to compete. In the absence of some "market failure," economists generally assume that most forms of competition will allocate resources more efficiently.

Market forces are driving some changes in the vertical scopes of electric utilities, but so are regulatory initiatives and political considerations that may not produce economically efficient outcomes. Superficially, the case for vertical deintegration is clear: since changes in technology have turned generation into a potentially competitive market, efficiency is best assured by allowing that market to operate. Transmission and distribution, however, remain most efficiently organized as monopolies, and should continue to be regulated. In reality, the case for deintegration is far more complex. Its advocates often argue from inappropriate analogies with other industries or nations, and disregard a large body of econometric research on the efficiencies of vertically integrated utilities.[2] If both integration and competitive markets have desirable economic properties, industry restructuring should focus on devising the most efficient mix of the two. The value of Integration between generation and transmission, however, has been conspicuously neglected. Because it has, restructuring may produce institutions that foreclose the realization of important efficiencies.

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[1] The "perfectly competitive" market model of economic theory does not consider activities such as these, since it assumes that all sellers are price-takers, that output is homogeneous, and that market information is costless to obtain. In this article "competition" always refers to rivalry between firms that can make strategic choices such as those in the text.

[2] Regarding other nations, deintegration is sometimes posited as an explanation for the fall in power costs after the formation of the United Kingdom's markets (Sant and Naill 1994). Shortly after the market was organized, real fuel prices decreased by 20 percent (coal) and 45 percent (gas) while labor productivity doubled. Increases in productivity are more likely a consequence of privatization than of deintegration. (Newbery 1997, 374)

Vertical deintegration is one policy that could remedy discrimination against competitors by an integrated utility. The law may require the company to transmit its own power and to honor requests from others to use its lines on the same terms, but it may also it may have reason to favor its own generation or customers. The economically efficient degree of deintegration is not obvious. The least extreme replaces a unified management of generation and transmission with a functional separation into administrative divisions. A step beyond lies structural separation, which creates subsidiaries that must deal at arm's length with each other. The preferred policy of the Federal Energy Regulatory Commission (FERC) is operational separation under an Independent System Operator (ISO) or Regional Transmission Organization (RTO).[3] Here utilities remain transmission owners but surrender control of it to a neutral organization.[4] The most extreme deintegration breaks generation and transmission into separate corporations, as occurred in the United Kingdom's privatization and restructuring.

To better understand vertical integration and markets, the next section of this paper summarizes the economics of vertical integration and its application to electricity. Section III then confronts the record of economic and legal thought on restructuring with the econometric evidence on integration. That research almost unanimously concludes that utilities enjoy strong economies of vertical integration. Competitive markets can also drive economic efficiency, but research on their performance in electricity has been less complete and often less rigorous. Section IV reviews economists' testimonies on vertical integration in the California restructuring, and Section V examines their views on ISOs. Quite often their views were at variance with existing research on vertical integration.

II. The Economics of Vertically Integrated Utilities

A. The Benefits of Integration

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[3] "RTO" has superseded "ISO" in FERC's terminology. Although their legal definitions differ the text uses them interchangeably.

[4] The question of nonprofit versus for-profit ISOs is discussed in Section IV below.

Generation, transmission, and distribution of electricity are highly interdependent. With minor exceptions, power cannot be stored and must be produced the instant it is wanted. Failure of generation to meet demand will result in blackouts. The demand for electricity has both random elements and predictable hourly and seasonal characteristics. Efficient response to both predictable and unpredictable events requires centralized operation of generation and transmission. Electricity can only be produced and delivered economically if highly specialized assets are in place. Distribution lines must physically reach users, and transmission lines must cover the distance between them and generation. For reliability some generators must be close to loads, while others may be more distant. Investment in generation and transmission is a long and costly process, and once in place the equipment cannot be cheaply redeployed to some other location or use.

Vertical integration is an efficient organizational choice if [1] assets are highly specific to a given use or location, [2] they are utilized in activities that must be coordinated, and [3] their best uses will depend on contingencies that are hard to predict. (Williamson 1971; Brickley *et al* 2004, 531) Market relationships are possible where there many possible trading partners exist and the costs of switching between them are low. Markets for nonstandardized goods or services are likely to be “thin,” with fewer potential sellers and greater complexity of transactions. Contracts govern some vertical relationships in electricity, for example between a utility and an independent power producer, or between a transmission-owning utility and a small municipal utility that depends on the other’s lines for deliveries. Even if a highly specific asset is under contract, its owner may act opportunistically, e.g. a generator may attempt to overcharge the utility if it knows that refusal to cooperate will cause a blackout. The utility may of course sue the generator, but its probability of success will depend on how a court interprets the details of a complex contract. A contract will be more difficult to negotiate and enforce if there is uncertainty about how and when the utility will require power from the generator.

Several attributes of electrical service make vertical integration an efficient organizational choice.[5] (Landon 1983)

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[5] For application of transaction-cost economics to the restructuring of other energy industries (and also electricity) see Van Vactor (2004).

Eliminating market distortions by eliminating markets. If a generator with market power (power to set price) sells energy to a utility for more than its marginal cost, economic inefficiency results. The utility might, for example, cease purchasing from the outsider and use owned generation that it would not operate if the price of that power were equal to marginal cost. The generation-owning utility will make efficient decisions by setting the internal transfer price of energy at marginal cost.

Coordination of investments in a complex system. Vertical integration facilitates the coordination of highly specific and interdependent investments in generation and transmission. The two are substitutes in the production of bulk power and complements in its delivery from generators to loads. Any new facility affects the economic value of all other facilities on the system, and an organization that owns most such facilities may also be most likely to understand their interactions and invest optimally in them.

Risk reduction and risk management. A vertically integrated utility may have less risk than one that operates under long-term contracts with generators. The probability of a blackout will be lower with coordinated operation of a large system. A utility whose plants burn coal from mines that it owns protects itself from increases in the market price of coal (but cannot benefit from falls in that price).[6] Greater certainty may lower the company's cost of capital, potentially important in so capital-intensive an industry.

B. Integration, Markets and Contracts

There are two broad alternatives to integration: markets and contracts. Markets are places or institutions where buyers and sellers compare their valuations of goods. Prices are discovered as information about offers and other market conditions becomes public. The cost of using a market instead of integration or contracting will be lower the easier it is: [1] to contact

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[6] Even if the probabilities of increases and decreases are equal, the regulated firm may prefer to own the mine to avoid protests from customers who see higher coal prices reflected in higher rates, but are not made aware of lower ones.

potential counterparties, [2] to compare their offers, and [3] to perform the transaction, whose costs may include the determination of product quality and buyer creditworthiness. Transactors are more likely to utilize markets to exchange relatively standardized goods in situations where information about their characteristics and the characteristics of counterparties is easy to obtain.

Markets offer alternatives in the form of substitutable products and uncommitted transactors. A seller who stops dealing with buyer A and starts dealing with buyer B does not need to make any investments specific to the relationship with B or lose any that were specific to the relationship with A. Specific investments, however, may increase the buyer's benefits or decrease the seller's costs, increasing the potential benefits for one or both of them. Assume a buyer wants a fuel supply with flexible deliveries, which requires that the supplier construct a specialized storage facility whose cost is unrecoverable if the buyer stops taking fuel from it (there are no comparable buyers nearby). The buyer only gets value if the facility is built, and the seller only builds it if the buyer commits to a long relationship. A contract between them may prohibit the buyer from procuring fuel elsewhere and the supplier from selling it to others when the buyer expects delivery. Contracts will supersede markets where a nonstandardized product (flexible delivery) is particularly valuable, where durable and specific investments are necessary to realize that value, and where the allocation of risk the parties prefer cannot be obtained in the market (for example, by using commercially available insurance).

Whether governance of a relationship will be by integration, markets, or contracts depends on their benefits and costs, possibly including the cost of changeover between modalities. Markets may become more attractive if their benefits increase (because they offer better alternatives than the buyer could self-provide at the same cost) or if the cost of using them decreases (Internet access allows quick worldwide shopping with lower risks of non-delivery). The benefits of contracting may likewise rise (Health insurance is more valuable to me if medicine is more advanced) or its costs are lower (without standardized automobile insurance, liability risks are so high that I choose not to drive). Integration can become a more attractive organizational form (if the market for a raw material input becomes more unstable) or a less attractive one (if growth of my industry means that specialist suppliers can make a component of my product more cheaply than I can). If the desirable scope of integration in electricity has in fact changed, it will have been the resultant of such forces as these.

C. Electricity's Changing Environment

To better understand vertical changes in electricity, first consider the unchanging interface between transmission and distribution, where restructuring has had no substantial impact. Both are highly specific assets, restricted as to location and transferable to non-electrical uses only at high cost. Competitive duplication of either is costly and sacrifices the scale economies and diminished line losses of larger conductors. The process of transforming voltages across the transmission-distribution interface is little changed, and second-by-second coordination of flows across it remains necessary. Vertical integration between transmission and distribution may in fact have become more valuable, if the growth of markets has increased uncertainty about fluctuating flows across the interface.[7]

Vertical deintegration is more likely between generation and transmission. FERC's "open access" rules (see below) requires transmission-owners to carry the output of independent power producers (IPPs) in a nondiscriminatory manner. IPPs now make up 45 percent of U.S. generation capacity. (FERC, June 10, 2004, 5) Although the assets are highly specific and require coordination, other attributes of electric energy may make markets desirable. It is a homogeneous commodity, can be centrally traded, and there are abundant alternatives for both buyers and sellers who choose not to use the central exchange. Market size is growing with FERC's RTO initiatives (see below), and the technologies of long-distance transmission and wide-area system controls are improving. Finally, economists and others have devised new market institutions to facilitate trade. Some short-term markets operate under two-settlement systems for

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[7] In the U.S., the lines on the two sides of the interface between a large transmission-owning utility and a small municipal distribution utility are separately owned. Power deliveries are usually under an all-requirements contract. If the municipal system owns generation elsewhere, the transmission operator integrates its output into the regional system and accounts for it in the price of deliveries to the city. The contracts governing this relationship limit the options of both parties with effects similar to those of vertical integration.

day-ahead and real-time transactions, ancillary services (load following and reserves) can also be traded, and some grids use Locational Marginal Pricing (LMP) of transmission.

All of the above facts imply that markets are more desirable today than in the past. They do not, however, imply that vertical deintegration is warranted because they do not consider its costs. Deintegration's net value also depends on the benefits of integration that will be foregone. If so, the policy question is determination of the optimal degree of deintegration. American restructuring, however, has not approached the problem this way despite the availability of some relevant research findings.

III. Restructuring and Economics

A. Through the 1970s: *Otter Tail* and Early Proposals for Competition

Economists have frequently studied horizontal mergers (between firms in the same industry) and the possibility that markets might become less competitive as suppliers become more concentrated. The U.S. government can file antitrust lawsuits to prohibit mergers or other restrictive practices that it believes will lead to monopoly. In horizontal merger cases the courts often agreed with economic theory, but prior to the 1960s theoretical research on vertical relationships was rare. The courts, however, were often called upon to evaluate vertical mergers and such restrictive vertical relationships as contracts that require a retailer to carry only the products of a single manufacturer. The courts often ruled that vertical mergers by large firms could extend market power at one stage of production into otherwise competitive stages.[8] In the 1960s and 1970s, economists came to the conclusion that the judicial view was generally incorrect. (Posner 1976, 147-211) First, a horizontal monopolist in one stage of a vertical chain (diamonds) does not need to merge with or acquire other competitive businesses (jewelry stores)

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[8] The key case is *Brown Shoe Co. v. U.S.*, 310 U.S.294 (1962). There the Supreme Court held that a shoe manufacturer's attempt to purchase a chain of retail stores was an attempt to use its market power in manufacturing to monopolize retailing.

to capture all the monopoly gains possible. The more efficiently the diamonds are retailed, the higher the wholesale price the monopolist can charge and the higher its profit. Second, if vertical mergers or restrictions cannot increase a seller's market power, their probable purpose is to turn the firm into a better competitor by reducing the transaction costs between stages of production.

Regulatory evasion provides a potential exception to this benign view of vertical relationships. In 1973 the Supreme Court decided *Otter Tail Power v. U.S.*, holding that a vertically integrated utility with market power in transmission had violated the antitrust laws by refusing municipal distribution utilities the use of its lines to deliver inexpensive power they had purchased for themselves.[9] Because the municipals had no transmission alternatives they had to take higher cost service from Otter Tail. The Court concluded that the company was attempting to monopolize distribution in its area, when competition for franchises was in fact possible. It further ruled that the government could order Otter Tail to transmit power to the towns if necessary. Guided by the *Otter Tail* ruling, scholars began to make their cases for the vertical deintegration of electricity.

Over the 1970s and 1980s lawyers and economists produced several proposals for deintegration, some still cited today.[10] They differ in numerous details, but all begin by considering long-distance transmission and local distribution as natural monopolies. All of them want greater competition between corporate utilities and local governments for franchises to distribute power. The reasons for encouraging franchise competition are unclear. Distribution is a standardized technology whose costs in most areas are under 15 percent of the delivered cost of power, and few if any real savings will result if a small municipality takes over operation of lines within its boundaries.[11] The authors of these studies also intended to facilitate the growth of

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[9] 410 U.S. 366. It appears that the court disregarded numerous facts that might have led it to a different decision. See Klein and Michaels (1994).

[10] Berlin *et al* (1976), Cohen (1979), Finery et al (1980), Landon and Huettner (1976), Meeks (1972), Pierce (1986), Weiss (1975).

[11] There are, however opportunities for cities to take advantage of certain legal provisions. Municipal debt in the U.S. is largely tax-exempt, and municipal utilities have priority over corporate utilities in the allocation of inexpensive power from federal dams. The latter fact motivated the requests for transmission service from Otter Tail.

energy markets by introducing competition by non-utilities for contracts with distributors and shared participation in new projects. At the time of their writings, continuing technological progress in large power plants and other factors actually made generation an unpromising market.[12]

The radical deintegrations that these authors proposed were based on a belief that even relatively small market benefits were worth pursuing, since they could be obtained by the simple (so they believed) step of breaking up corporate utilities. In particular they unanimously asserted without proof that vertical deintegration would produce few if any efficiency losses:

> The reduction of competition at the distribution stage might be acceptable if vertical integration made utilities more efficient. That, however, is not the case. Utilities strive to integrate forward to obtain a dependable supply of bulk power. But vertical integration does not significantly reduce the cost of operation at any stage of the industry.[13]

Some tried to prove their cases by analogy:

> [I]n other industries, production has not, for the most part, been integrated with distribution. There is today no compelling reason for such integration in electric power either.[14]

References such as these continue to guide some policy makers. They do so despite the fact that shortly after these studies were published economists began attempting to estimate the benefits of vertical integration. Almost uniformly their findings would contradict the claims these studies made about deintegration.

B. Econometric Studies Of Vertical Integration

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[12] Economies of scale in coal-fired plants were near their highest point, nuclear facilities were still feasible, hydroelectric sites were becoming scarce, and natural gas was in shortage due to price controls. The technologies and laws that allowed independent power production to thrive were not operative at the time of most of these writings.

[13] Cohen (1979, 1524). His footnoted references are Meeks (1972), who also provided no useful sources, Weiss (1975), who acknowledged that studies were needed, and an economist who still testifies today on behalf of municipal utilities at FERC.

[14] Meeks (1972, 82). His evidence was to note the existence of power contracts between utilities, and between utilities and the federal government.

1. Generation, Transmission, and Distribution

There are at least eleven published studies of how the vertical integration of generation, transmission, and distribution affects utilities' costs.[15] They cover the U.S. and Japan, both of which are served by regulated, vertically integrated corporate utilities with assigned territories. Their data cover subsets of years between 1970 and 1997, all taken from utilities' annual filings with regulatory agencies under standardized reporting systems.[16] In the U.S, a utility's vertical integration can be quantified as its degree of self-sufficiency in generation. Some companies own generation in excess of their own loads, others are purchasing some power at all times, and still others are operating units of holding companies that control several utilities. There are a few unintegrated utilities that only generate for wholesale sales or only distribute purchased power.[17]

[15] This paper does not discuss some other forms of integration examined by economists. They include cost comparisons between utilities that sell only electricity and those that sell electricity and gas (Mayo 1984, Hartman 1996), and estimates of economies of scope from serving several types of customer (Gegax 1984)

[16] This is the case in the U.S. The authors of the Japanese studies do not comment on the consistency or accuracy of their data, which may mean that they too have few such problems.

[17] Several of the researchers exclude the unintegrated systems from their data sets. Some of the samples treat a holding company as a single observation, while others include each of their operating companies.

Table 1 summarizes their methods and findings.[18] The only study to find that vertical integration creates diseconomies is the most questionable on several grounds.[19] Among the others, only one author finds no statistically significant cost complementarities between generation, transmission and distribution.[20] Because the authors utilize different samples and research techniques it is impossible to compare their numerical estimates of the savings from integration, but with the exceptions mentioned above they are all significantly positive.[21] All of the studies use variants of two basic strategies to estimate vertical economies. The first is to estimate a cost function (usually translog, otherwise quadratic) on the assumption that the output of each stage (generation, transmission, and distribution) is from a multiproduct firm. The sizes and signs of the coefficients of their interaction terms then provide evidence on economies of vertical integration. Some formulations allow tests for economies of scope (and invariably find them), i.e.

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[18] One remaining study is not directly comparable to those on the table. Steiner (2000) uses 1986-1996 annual data from 19 OECD countries to examine the effects of restructurings. She attempts to explain variation in capacity utilization, deviations of actual from optimal (assumed 15%) reserve margins, prices to industrial users, and the ratio of industrial to residential prices, using random effects regressions that include measures of restructuring and privatization. Vertical deintegration (separation of generation and transmission) is associated with significantly higher rates of generator capacity utilization and smaller deviations of actual from ideal reserves, as is her measure of privatization. She finds that prices to industrial users are not significantly associated with vertical deintegration, but the ratio of industrial to residential price is significantly lower in nations that have unbundled generation and transmission or that have a power pool. Results like these are almost surely sensitive to regression specification, particular with international data. Her only published results, however, are summaries of single regressions for each of the four performance measures.

[19] That study, by Eftekhari (1989), defines some variables in unorthodox ways. His measure of interconnection activities includes the algebraic sum of interchanges into and out of a utility's territory, which could be zero for a large trader. One of his output variables is sales to ultimate customers as a fraction of total sales, rather than an amount. In any case his estimated cost function carries the implication that utilities should always either specialize completely in retail sales or in sales of power to other systems, rather than any mix of the two.

[20] Cost complementarity means that the marginal cost of producing one good decreases when output of the other is increased. Gilsdorf's (1994 and 1995) findings of no cost complementarity are still potentially consistent with economies of scope and economies of vertical integration, and his estimates show unexploited returns to scale in each of generation, transmission, and distribution.

[21] It is possible but not likely that these results are tainted by selectivity bias. "Perhaps integrated utilities have been formed by merger or are tolerated by regulators because of higher efficiency." (Pollitt 1995, 33) The implication is that these estimates should include unobserved characteristics of individual firms that lead some of them to vertically integrate and others not to. Most if not all U.S. utilities have been vertically integrated since their formation, rather than being created by e.g. mergers of generation and distribution operators.

whether the sum of costs of standalone firms producing each of the stages exceeds the cost of final output in an integrated firm. The second strategy estimates cost or production functions for each stage and then tests for vertical separability by examining whether output of an earlier stage significantly lowers the costs of a later one. If it does, vertical effects are present and the production process is not separable.

2. Fuel Supplies and Generator Performance

Research on generation, transmission, and distribution primarily studies the effects of vertical integration on production cost. Research on the integration of fuel supplies and the outsourcing of generator engineering and construction, by contrast, is about integration's transaction cost aspects.[22] Joskow (1985) tests whether a model of asset specificity can predict when a coal-fired generator will burn fuel from a mine operated by its owner rather than purchase it. Greater specificity (in either the generator or the coal supply) should be more likely to entail integration between the mine and the utility. His findings are generally consistent with this theory: [1] Only a small amount of coal is traded in spot markets, and trades are primarily in the east, where there are more mines and more generators than in the west.[23] [2] Mine-mouth plants are more often designed to burn a specific type of coal than non-mine-mouth plants, and to be integrated with utility-owned mines. (Joskow 1985, 65) [3] In non-integrated situations, greater relationship-specific investments mean longer contracts – coal supply contracts are on average twelve years longer for unintegrated mine-mouth plants than for plants not located there. Longer-term contracts will be for the generator's full requirements and contain complex market-based price adjustment terms (Joskow 1985, 54) [4] Long-term contracts are more common in the west, where a plant must burn low-sulfur coal compatible with the details of a generator's engineering,

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[22] In addition to the works discussed below, one study details the range of data on utility operations required to optimize and evaluate a demand-management program, and makes clear that a vertically integrated utility minimizes difficulties in obtaining and analyzing that data. (Orans 1994)

[23] Joskow (1985), 51; Joskow (1987), 172. Most generators in the eastern U.S. operate with pollution control technologies that allow them to burn coal with a range of sulfur content. Those in the west are more often engineered to use low-sulfur coal from a particular mine.

than they are in the east, which has numerous interchangeable coal sources. (Crocker 1996, 92, citing Joskow 1987)

Regulation can change the costs and benefits of integration into mining. Filer (1984, 219) found that the most important determinant of integration is the presence of a fuel cost adjustment provision in rates, which might allow utilities to opportunistically overstate the costs of mining to obtain higher rates. Likewise, Gonzales (1979) found that productivity is lower in utility-owned coal mines than in independent ones. Some utility-owned mines, however, are unregulated and their productivity is the same as that of independent ones.[24] By contrast, Kerkvliet (1991) found that vertically integrated mines were more technically efficient than unintegrated ones, i.e. with a given mix of inputs an integrated mine would produce more than an unintegrated one, other things equal.

Generator performance provides a more indirect and less conclusive test of the transaction-cost model. Joskow and Schmalensee (1987) examined the operational heat rates and unit availability of low-pressure “subcritical” and high-pressure “supercritical” coal-fired units. Their regressions included indicator variables for the four utilities that were the largest owners of these plants and performed their own design and engineering work. Other utilities outsourced these functions. For both types of generator, two of the four integrated owners enjoyed significantly better availability and heat rates than average, while the other two companies were at the average.

C. Vertical Integration and Reliability

There are no publicly available studies that estimate the actual or potential effects of vertical deintegration on reliability. Noteworthy outages are rare in the U.S. and reliability analysts are justifiably more interested in their proximate causes (equipment malfunction, trees touching

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[24] Gonzales (1979), 131. He also finds that productivity is lower when a regulated mine operates under a cost-plus contract with the buyer. He cautions readers that his findings do not by themselves make a case for deintegration, since he has not studied the possible benefits of integrated mines.

lines, etc.) rather than their relationships to changes in industry structure. Potentially important structural changes may include vertical deintegration, the formation of RTOs, growth of existing wholesale markets, and direct access of final customers to non-utility suppliers. All of them make operations more complex and possibly riskier, but there is no clear way to apportion the causation of outages among them. There have been further concerns that more extensive restructuring will adversely affect investment in transmission, since cost recovery may be at risk if unforeseen market changes leave a new line underutilized. These effects could worsen already-existing problems that have been caused by twenty years of insufficient transmission investment. (Hirst 2004; NERC 1998, 7)

The North American Electric Reliability Council (NERC) has for some time been concerned about the effects of restructuring on reliability.[25] Its annual reliability assessments discuss the consequences in general terms:

> The responsibility for coordinating operations between generating plants and transmission systems traditionally has been assigned to the utility transmission system operators and system planners. Administrative separation [i.e. vertical deintegration of generation and transmission] as well as the growing number of [independent power producers] demands a more standardized and formal understanding of the bulk electric grid control and reliability criteria by all. (NERC 1998, 38)

NERC also sees inefficiencies resulting from uncoordinated planning and investment decisions.

> The close coordination of generation and transmission planning is diminishing as vertically integrated utilities divest their generation assets and most new generation is being proposed and developed by independent power producers. Once new generation is announced the necessary transmission additions to support it must still be designed, coordinated with other generation and transmission, and constructed. Since these activities are no longer carried out within a single organization, more time will need to be allowed to coordinate and perform these tasks to properly integrate the new generation to ensure reliability before it can come into service. (NERC 1998, 7)

NERC's concerns about operating difficulties may be justified, but its reports do not discuss any actual outages or operating crises that it believes were caused by vertical deintegration or increased reliance on markets. The organization's data do, however, show increases of several

[25] NERC is the coordinating agency for ten regional electric reliability councils that cover most of the continent. Members of those councils include corporate utilities, independent power producers, governmental utilities, and cooperatives. (NERC 1997, 3)

hundred percent between 1998 and 2004 in emergencies that required the use of extraordinary procedures for redispatch and curtailment known as Transmission Loading Relief (TLR).[26]

The increase in TLR probably has multiple causes. There has certainly been increased stress on the transmission system due to deficient investment. NERC (2001, 25) also blames changes in the pattern of grid use, as systems designed for predictable transfers between utility-owned generation and captive loads are required to accommodate unpredictable flow patterns that result from market transactions. There has also been concern that a vertically integrated utility can exercise market power if it calls for TLR in a non-emergency situation. TLR protocols on capacity reservation and service curtailment can at times give priority to the transmission owner's own generation over transactions by competitors that use the same lines. Attorney Diana Moss (2004, 25) concludes that determining whether emergencies or market power explain TLR growth will require further research.[27] If vertically integrated utilities actually do invoke TLR for strategic reasons, it will be as a consequence of the particular TLR rules in effect rather than of vertical integration itself.

Moss' work more generally addresses potential conflicts between competition and reliability that deintegration and market growth may have aggravated. She recognizes, however, that inefficiency and threats to reliability can also result from the absence of market forces. For example, if transmission is sold at regulated rates that recover average cost rather than priced in a market to reflect its scarcity, there may be little investment in new lines and those that are actually built may be inefficiently located. (Moss 2004, 17) By contrast, NERC appears to believe that engineering standards should generally take precedence over market outcomes.

> [Due to vertical deintegration] generation additions cannot be planned in an integrated fashion with transmission expansion, resulting in sub-optimal transmission expansion in some areas. Generation is not locating close to demand centers, but rather is locating

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[26] The current TLR procedures have been in place since 1997. There are five different levels of emergency. The figures in the text refer to the three most serious ones, whose growth rates have all been high. A graph and source data are available at ftp://www.nerc.com/pub/sys/all_updl/oc/scs/logs/trends.htm

[27] A small number of transmission-owning utilities have been responsible for a large percentage of TLR incidents. This, however, can reflect either the weakness of their grids or their abundant opportunities to exercise market power.

> close to a fuel supply, adequate cooling water, and a transmission line interconnection. (NERC 2001, 25)

The interrelationship between investments in generation and transmission leads NERC to favor planning by utilities over reliance on markets. Beyond this statement, however, NERC provides no discussion about which decisions it thinks are best made in markets. In electricity, the choice between planning and markets is a matter of degree: vertical integration and centralized planning yield operating economies, but markets may at times provide efficiency benefits that outweigh the losses from less comprehensive planning.

An alternative vision to NERC's has recently surfaced. FERC is considering several proposals to allow "participant funding" of additions to RTO grids by generators and others.[28] A 2002 proposal to form SEtrans, an RTO in the Southeast, envisioned participant funding as one of two types of transmission investment.[29] The SEtrans applicants expected that lines linking new generators to the grid would usually be participant funded since their benefits accrued primarily to their builders. Some other lines (often planned by the RTO) would bring more general benefits in the forms of increased reliability and improved access to markets. Their costs would be prorated ("rolled-in") according to agreed-upon formulas. SEtrans had good reason to propose participant funding: its area contained fuel supplies and generator sites that might produce power for distant consumers, but these generators would add little to reliability. Further, mandatory cost-sharing might allow inefficient transmission investments that would not have been made if beneficiaries had to bear their full costs.

One representative of a large utility in SEtrans saw the failures of past planning as further reason to institute participant funding. In his view the ability of grid planners to make efficient long-run choices is doubtful. Seeing that today's industry faces unprecedented uncertainty about load growth, market development, new technologies, and fuel prices, he said that "[w]e cannot

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[28] Participant funding is also embodied in recently issued rules for generator interconnections. See Standardization of Generator Interconnection Procedures and Agreements, 106 FERC ¶ 61,220 (2004)

[29] Cleco Power LLC *et al*, Order Granting Petition for Declaratory Order, Docket No. EL02-101-000 (Oct. 10, 2002). SEtrans withdrew its application in 2003 due to conflicting demands of state regulators and FERC.

optimally plan the transmission grid any longer, and we should not try and pretend that we can."[30] A centrally planned RTO must choose which lines to build or upgrade from numerous alternatives, each of which might be consistent with reliability. Participant funding gives these decisions to the market, where pressure to make efficient choices may be greater. Lines that create benefits for the entire region might still best remain under the ownership of vertically integrated utilities. (However funded, all of the lines in the area must still ultimately be under the control of a central operator.) Harvard economist William Hogan (2004) recently noted that a "free-rider" problem might arise if lines are differentiated in this manner. An entity that would normally propose a participant-funded line may prefer to wait until its absence begins to affect reliability, at which time the RTO might authorize collective funding. Thus far, the search for a clear distinction between lines that should be participant funded and those needed for reliability has produced no operational criteria for making that distinction.[31]

D. Conclusions

The movement to restructure electricity began with generalities about the desirability of markets, coupled with claims that vertical integration in utilities was either unimportant or its effects could easily be duplicated in markets. The econometric evidence makes clear that there are substantial economies of vertical integration, although further comparisons among the individual studies are difficult to make. The case for deintegration and restructuring has implicitly been founded on a belief that the savings and other benefits obtainable from markets exceed those that are associated with vertical integration. It is quite possible that utilities invest or operate inefficiently. Rate of return regulation may induce them to overcapitalize or to extend themselves excessively into unregulated businesses. As regulated monopolies they may feel less pressure to cut costs than firms in competitive markets. With rate of return regulation, vertical deintegration by itself is unlikely to produce more efficient operation or investment. Performance-

[30] Statement by Bruce Edelston, Director of Policy and Planning, Southern Company, quoted in Radford (2003).

[31] A recent unpublished paper by Michaels (2004) proposes use of a demand-revealing mechanism to circumvent free rider problems.

based or price cap regulations are less drastic alternatives to deintegration (which will be largely irreversible after it is undertaken) and have shown some success in practice. If markets are superior to utilities in some activities, can their benefits be obtained by policies that also maintain the benefits of integration? Such questions have gone largely unasked as the U.S. industry restructures.

IV. Vertical Integration in Restructured Power Markets

A. Vertical Integration and the California Restructuring

On April 20, 1994 the California Public Utilities Commission (CPUC) instituted a rulemaking on electricity.[32] Its radical proposal to allow consumers "direct access" to suppliers of their choice generated volumes of testimony from interest groups, most of which are no longer available on the Internet.[33] The CPUC held hearings in 1994 and early 1995, and in December of that year issued its initial order. The legislation enabling formation of the California Power Exchange (PX) and Independent System Operator (ISO) was passed in September 1996, and the FERC proceeding to approve market-based rates in them extended through 1997 and beyond.[34] The markets opened for business on April 1, 1998. In the months after the California filings, FERC began to process applications to form exchanges in other parts of the country, particularly the northeast.

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[32] Order Instituting Rulemaking, Docket No. 94-04-031 (April 20, 1994). This document came to be known as the "Blue Book," from the color of its cover.

[33] In 2002 the CPUC decided to remove all of these testimonies and the Blue Book itself from its web site, for reasons that it has not made public. They are still accessible at the Commission's offices.

[34] FERC's statutory obligation is to regulate "just and reasonable" rates in wholesale transactions. Prior to the coming of markets this required comparisons between proposed prices and production costs. In the 1980s FERC began allowing rates to be set by market prices in areas where suppliers were unconcentrated enough (according to criteria set by the commission) that competitive conditions would neutralize any market power one of them might try to exert.

Perhaps the most frequently expressed opinion on vertical integration before the CPUC was a belief that it was undesirable in a regulated world, and in a deregulated system it would facilitate the exercise of market power by utilities. Testifying for municipal utilities, economics professor William Shepherd either rejected or was unaware of the research discussed in the previous section. He claimed that in order to achieve economies of scale and scope "[t]here may need to be separation of the core functions into distinct entities."[35] (He provided no evidence that unseparated utilities failed to exhibit economies of scale and scope.) Others proposed radical restructurings along the same lines, not necessarily restricted to California. They included energy law professor Richard Pierce (1994), who failed to mention any possible costs of deintegration in a scheme to separate generation from transmission and transmission from distribution.[36] In New England, Environmental Economists David Moskovitz and Douglas Foy (1994) proposed to solve the stranded cost problem with a deintegration that included a sale of transmission at premium prices to pay them off. In Nevada, another group suggested vertical deintegration of corporate utilities and the founding of a nonprofit transmission company in order to pay the utilities' stranded costs and obtain tax advantages. (Blank *et al* 1996)

The two founders of independent power producer AES attempted to make the quantitative case for vertical deintegration by citing the post-privatization drop in U.K. generation costs, but failing to attribute most of it to lower fuel prices.[37] They also describe but do not cite an "analysis [that] suggests divestiture of generation will lower overall costs per kwh by 15 percent," and an unpublished consultants' report that the saving will be from 20 to 40 percent.[38] Perhaps the most surprising views were those of Economist Irwin Stelzer (1996), retired founder of a consulting firm whose clients include many integrated utilities. He asserted that competition was impossible as

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[35] Shepherd 1994, 23. He did not cite any of the research discussed above, but warned that existing utilities would claim that vertical separation "will cause large inefficiencies, even when those claims are false."

[36] His earlier writings (Pierce 1986) did describe the possible benefits of vertical integration, but asserted without evidence that deintegration would be worth this cost.

[37] See note 2 above.

[38] Sant and Naill (1994, 51). The probable source of the 15 percent figure is Naill and Dudley (1992) whose itemization of savings yields a range of estimates between 5 and 15 percent.

long as utilities were vertically integrated, and proposed that utilities deintegrate as a precondition for stranded cost recovery. None of these authors brought up the possibility that integration could also be beneficial.

A few experts called for a balance between the costs and benefits of vertical integration. Two economists from the University of California Energy Institute wrote that

> "[i]f the vertically integrated utilities remain largely intact.... their coordination abilities could enhance reliability and reduce transaction costs. However, the utilities would also have a correspondingly large capacity for the exercise of [horizontal] market power. If the utilities are dismantled along the lines of the UK model, then new mechanisms for coordination would have to be developed."[39]

MIT engineering professor Marja Ilic and her associates described the requirements for operating methods and software that had yet to be developed if an ISO in a vertically deintegrated system was to operate a well-functioning set of wholesale and Direct Access markets for both energy and ancillary services.[40] Only two works by economists prior to the opening of California's markets brought up any of the econometric studies of integration discussed above.[41] Both of them provided cautionary discussions on the value of integration, and one noted that prior to deintegration its advocates should show that "cost savings exceed foregone economies."[42]

After over a year of hearings and negotiations, the CPUC issued its Initial Decision in December 1995. The wholesale pooling and retail access aspects of that decision would be altered before markets opened, but its generation divestiture provisions would remain. They required that the state's two largest corporate utilities divest themselves of 50 percent of their

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[39] Blumstein and Bushnell (1994, 19). At the time of their writing the concept of an ISO had not yet been developed.

[40] Ilic *et al* 1996. Problems like those she describes complicated operations in the early years of the ISO and PX.

[41] Gegax and Nowotny (1993), Hill (1997). The integration studies are also mentioned in a report by the Consumer Federation of America (2002, 31), a political advocacy group usually sympathetic to regulation.

[42] Hill (1997, 53). I have encountered no subsequent citations to this article.

fossil fuel generating capacity located in California.[43] A Commission majority justified this radical step by stating (without evidence) that "the vertically integrated electric utility is not compatible with the institutions of a competitive market for electric services." That utility structure is "rooted in the past and incompatible with emerging markets." (D.95-12-063, 10 and 90) The decision cited no testimonies or other evidence on the benefits of vertical integration or the possible costs of a breakup. The utilities accepted the decision primarily because it would guarantee recovery of stranded costs, and allow them to maintain some competitive advantages even after direct access began.[44] The 1996 legislation authorizing the PX, ISO, rate freeze, and stranded cost recovery imposed the same divestiture requirements, again with no discussion of the costs and benefits of integration.[45]

Stranded costs were primarily an issue for state regulators, and testimonies in FERC's market-based rate proceedings centered on the ability of vertically integrated utilities to leverage market power from transmission to generation and distribution. The standards for market-based rates require an applicant to delineate geographic markets for short-term energy and capacity, and possibly other commodities. The applicant must then show that it (in this case, California's three large utilities as a group) controls a small enough part of the market that its power over price is minimal. The utilities were unable to meet FERC's standards. Intervenors (protesting parties) compounded the problem with testimonies claiming that the utilities' horizontal dominance of generation left them ideally suited to use their transmission to exercise vertical market power, and that even an ISO might not suffice to neutralize it, at least prior to actual divestiture of the plants. The unities responded by proposing additional market power mitigation measures, including an independent monitor and special contracts for the pricing of generation required to operate for

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[43] CPUC, D.95-12-063 at 98. The units in question were gas-fired and under normal conditions would set price in the new markets. Ultimately these two utilities chose to sell all of their in-state gas-fired capacity to independent power producers.

[44] One economist from a utility, however, commented that "[t]he record in the CPUC case provided no evidence of a market power problem that needs to be resolved through divestiture." ("Calif. PUC Votes," Dec. 25, 1995, 1) A Southern California Edison Vice-President wrote that requiring the divestiture of generation "reduces competition" because it removes a competitor from the market (Budhraja 1996, 60) (It also adds new competitors who bought the units.)

[45] Currently in California Public Utilities Code. The law is still commonly known as Assembly Bill (AB) 1890.

reliability.[46] The utilities were the only parties one would expect to defend vertical integration, and in more normal circumstances they might have done so. Here, however, stranded costs were their prime concern and they would reluctantly accept vertical deintegration as the price of recovering them. Thus the record at FERC is essentially devoid of any discussion of vertical integration beyond conjectures about market power.

Prior to the opening of California's markets, most interested parties viewed vertical integration as a tool for the exercise of market power by utilities. The utilities also enjoyed horizontal market power as owners of most existing generation. Regulators and others believed that the combination of divestiture and an ISO might suffice to mitigate both types of market power, particularly during the limited time California gave its utilities to recover most of their transition ("stranded") costs.[47] The CPUC required the two largest utilities to divest half of their in-state gas-fired plants, but ultimately they chose to divest all of them to six different independent power producers and marketers.[48] By FERC's standards for horizontal market power, the area was now sufficiently competitive that the prices arising at the PX and ISO would not be subject to further regulation.[49] For the first two years of the markets prices hovered near marginal cost, but by spring of 2000 they had begun their rise to crisis levels. Numerous factors contributed to the problem, and are still the subjects of litigation and academic debate. One possible factor that simple measures of seller concentration could not predict was market power exercised by the

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[46] FERC, Order Conditionally Authorizing Limited Operation of an Independent System Operator and Power Exchange, Docket Nos. EC96-19-001 (Oct. 30, 1997);"California's Three Major IOUs," April 16, 1997, 8.

[47] The law allowed utilities to recover their transition costs in the difference between frozen retail rates and market-determined wholesale energy costs prior to 2002. Most market power studies submitted to FERC were concerned with monopolistically high prices, but the law's provisions made utilities more interested in low market prices. Some intervenors did express concerns about monopsony (market power of a buyer) and predatory pricing. The law also required utilities to apply any premia between the sales prices and book values of divested plants to stranded costs.

[48] The third-largest utility, San Diego Gas & Electric, also divested its gas-fired plants as a condition imposed on its later merger with Southern California Gas to form Sempra Energy.

[49] FERC utilizes critical values of the Herfindahl-Hirschman Index of supplier concentration, a standard tool of antitrust analysis equal to the sum of squares of the market shares of all competitors. In some models of oligopoly it predicts that increased concentration will lead to higher prices, but in others it does not. See Michaels (1996).

owners of divested generation. If generation is near its limits, transmission is scarce and demand is highly inelastic, a single generator might move the market price with a small change in output, and others would have reason to bid above their marginal costs as well.[50]

B. Vertical Integration after the California Collapse

Three years after California's markets began operating, its Power Exchange was bankrupt and its utilities in disastrous shape. Only after their deintegration did economists begin rethinking the relationship between vertical integration and market power. This time their conclusions were quite different. New models showed that integration could actually constrain rather than enhance a generation owner's market power. A generator required to serve final demand has little reason to cut the output of plants that it owns unless it can obtain power more cheaply from a market. (Wolak 2003a, 2003b) Forward contracts that commit generators and users to fixed delivery prices likewise diminish the incentive for a generator to exercise market power with its uncommitted plants. (Wolak 2000, Bushnell and Saravia 2002).[51] Vertical deintegration was not solely responsible for California's problems, but a consensus arose that it facilitated the exercise of market power by owners of the divested plants in ways that would not have happened if the utilities had remained vertically integrated.[52] As this was happening, the utilities began their long journey back to financial health and found themselves with an opportunity to vertically re-integrate.

Between 1998 and 2003 a binge of merchant powerplant construction had left many of the non-utility generators either bankrupt or in poor financial health. The markets they had expected to materialize as states restructured had largely failed to appear. Over those years total U.S.

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[50] Duane (2002, 508). The CPUC documents he cites are no longer available on the Internet.

[51] This argument contains an unstated assumption that makes it empirically questionable. It assumes that forward contracts are for some reason usually priced below the spot prices that will actually prevail in the future.

[52] Mansur's study of utilities in PJM tests some hypotheses on vertical integration. Among other tests, he estimated that the two companies in Pennsylvania with the lowest retail loads (smallest forward commitments or smallest vertical constraints on their behavior) were producing 14 percent less than they would have in a competitive environment, and they were the only two utilities in his sample to do so.

generation increased from roughly 800 GW to 1,000 GW. 150 GW of the increase had been built by IPPs. (FERC June 10, 2004, 5) Over only ten years, the ownership structure of generation had changed dramatically. In the mid-1990s approximately 90 percent of generating capacity was owned by utilities. Today, new plants and divestitures have left only 55 percent of the national total under cost-based regulation. 60 percent of the remainder is owned by unregulated affiliates of utilities. Overoptimism on all sides allowed independent powerplants (usually under project finance) to be funded largely by debt. By 2004, 90 GW of them had been turned back to lenders, 23 GW had been bought by private investors, and 10 GW had been purchased or repurchased by regulated utilities.[53] These changes may be evidence that vertical integration is returning to the industry.

As the finances of the IPP sector deteriorate, the distressed assets have often been priced so attractively that purchase by utilities or their affiliates is clearly efficient. According to some, however, these purchases raise antitrust concerns because they needlessly re-concentrate suppliers in regional energy markets.[54] Vertical integration is also being pursued more directly. Two of California's three large utilities are building new generation and the third is applying to the CPUC for permission to do the same. Under new state laws, California intends to reregulate and reverticalize utilities in hopes of avoiding a repetition of the 2000-2001 crisis.[55] Utilities must now file short-term and long-term resource plans with state regulators, who approve individual investments, set reserve requirements, and impose "renewable" resource quotas on them. California utilities are also attempting to slow the growth of distributed generation (very small facilities on end-user sites). They claim that restriction of its scope is necessary for reliability, while others claim that they are trying to eliminate competitors. (Stavros 1999, 34)

C. Lessons Learned about Vertical Integration

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[53] Figures are from testimony by Jone-Lin Wang of Cambridge Energy Research Associates at a FERC Technical Conference. (FERC, June 10, 2004, 5-7).

[54] See FERC.June 10, 2004, testimonies of Peter Esposito and Diana Moss (antitrust concerns) and Christine Tezak (few antitrust concerns).

[55] "California's Electric Utilities File," (April 23, 2003), 10.

There has been little pressure for reintegration by either utilities or the public in those states where deintegration has been accompanied by relatively successful market outcomes, e.g. Massachusetts and New York. These market outcomes may reflect no more than temporarily advantageous supply and demand situations, as California's did during its first two years. In particular, there are no available research findings about the effects of either deintegration or RTO membership on the operating efficiency of utilities. It may be possible to perform studies comparing utilities before and after they became members of RTOs. The only available related study (unpublished) is by Delmas and Tokat (2003), who found that deregulation of retail access has a generally negative effect on utilities' productive efficiency. Consistent with the predictions of organization theory, they found that vertically integrated utilities that supply the full requirements of their retail customers experience smaller efficiency losses from the opening of retail markets, and so do those that purchase their entire power supplies on wholesale markets. Utilities that must mix market purchases with internal production suffer efficiency losses greater than those at the extremes.

California's performance has brought a general agreement on the value of requiring transitional contracts between utilities and the owners of divested generation.[56] A transition from integration to unbundling induces new price risks for both generators and retailers, since generators sell at the wholesale price while retail rates are usually fixed. In an integrated utility, these cancel out, but a deintegrated system will probably require contracts to allocate the obligations and risks.[57] Economists have provided little guidance on how long this period should be, or on other characteristics of the contract. Utility CEO Rowe and his co-authors (2001) believe that a major difference between California and Rowe's utilities (in Philadelphia and Chicago) was that regulators in his states allowed divestitures to be determined by the utilities

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[56] Mansur (2003, 36). He also notes that "These results do not imply that divesting powerplants was a poor decision. However, it does caution regulators that , if they do require divestiture, then they also enable firms to sign contracts that will limit incentives to distort the market."

[57] Newbery (2002, 6). The British contracts ran for three years. He also makes the interesting point that although many electricity industries have been restructured successfully, they all started with substantial spare capacity." (2002, 10). California began with enough excess capacity that for its first two years many generators could not cover their full costs at market prices. A rare constellation of events destroyed that excess more quickly than the state's utilities expected it would.

themselves, and they also allowed contracts and hedging.[58] Rowe also discusses the value of a properly planned transition. In Pennsylvania, the time paths of stranded cost recovery were determined in settlements with individual utilities, and surcharges to their rates were set in advance. Only one of Pennsylvania's utilities chose to divest,[59] Instead of a discontinuous institutional break like California's, the PJM markets were imposed on a "tight" centrally dispatched regional power pool that had operating and settlement mechanisms in place. As a further safeguard, generators were required to submit only cost-based bids during the first year after PJM's markets opened. New York, however, offers a potential counterexample to Pennsylvania. Its regulators increased utilities' uncertainty by requiring divestitures prior to formulating any stranded cost policy. They did, however, allow (but not require) contracts between utilities and owners of the divested plants.[60] Most of those contracts will expire in the near future.

Partial vertical integration may be a sound strategy for utilities that expect to serve substantial amounts of load that have chosen not to leave regulated service.[61] In the future many utilities will have some customers who obtain their own power supplies and others who are either "captives" legally prohibited from using the market or who choose not to do so. Read (2004) observes that their "provider of last resort" functions are no longer expected to be transitional, and vertically deintegrated utilities must design efficient procurement plans for their core customers. Utilities that have sold their powerplants and lost their safe monopolies will have lower quality credit, which will affect their decisions to build generation or buy energy. Read sees re-verticalization by asset ownership at one extreme, providing the hedge that only physical assets

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[58] Rowe's Chicago utility divested its fossil and nuclear plants, while the Philadelphia company divested only nuclear. Along these lines, Green and Newbery (1997) supported deintegration for large British suppliers but not for small utilities in Scotland. As in California, retail rates in Pennsylvania were also capped.

[59] That utility, GPU, encountered financial problems when wholesale rates rose and customers in its area began abandoning direct access to return to its capped retail rates. State regulators refused to grant the company relief, saying that GPU should live with the consequences of divestiture and refusal to hedge. "To Avoid California Experience," (Jan. 22, 2001), 16.

[60] "New York Rebuts Idea," (Jan. 29, 2001), 16.

[61] Kiesling (2001, 23), one footnote omitted.

can but also inviting regulatory scrutiny about prudence. That scrutiny will be more likely if the load served by these assets chooses to depart. At the other extreme is a portfolio model, in which the utility holds nothing but contracts and uses the spot market to provide for any excess load or to dispose of excess contracted power.[62] California's utilities are in transition toward an intermediate mix, but one that will be heavily weighted in favor of utility-owned assets and longer-term contracts. Utilities will have a continuing interest in well-functioning bulk power markets, although the degree of interest may depend on whether existing customers can also depart and use those markets.

D. Conclusions

Some retrospective studies have asked why restructuring attracted so much support, given its goal of moving a vital industry into largely unknown territory. A slower opening of markets to direct access by large customers would certainly have been feasible. As the difficulties of administering the limited market were resolved, transactions could have been opened to smaller customers. The market's scope would be market-determined rather than regulator-imposed.[63] A few economists even question whether markets should have been opened at all. Rosen (2000, 32) has attempted to make a qualitative showing that the cost of creating and using markets in a deintegrated system is probably not worth the economies of integration that were sacrificed.[64] He (2000, 112) goes on to state his belief that many industry analysts were blinded to the costs of massive restructuring by a long-standing and sometimes justifiable dissatisfaction with the performance of regulation. Other economists argue that restructuring has been a success in most

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[62] Read (2004) also suggests that a utility could auction the right to serve its residual load to an independent organization.

[63] Experts initially viewed the breakup of American Telephone and Telegraph (AT&T) as valuable to only a handful of large businesses with extensive telecommunications requirements. Within two years, new service providers were selling to individual residences.

[64] He also notes some potentially harmful externalities that have not yet been realized. For example he questions whether the choice of new generation investments should be in the hands of parties who do not bear the risks of excessive reliance on natural gas.

states and nations that governed it with rational legislation and regulation. Kiesling (2001, 23) believes that deintegration itself can and should be market-driven:

> The encouragement of restructuring of utilities created substantial flexibility in Pennsylvania's electricity market. Divestiture is likely to occur to some extent as a part of restructuring, when utilities refine their "core competencies." Allowing retention of at least some generation capacity enables companies and consumers to reap the benefits of vertical integration where they exist.

The California restructuring process could have been a forum for reasoned discussion on the future of vertically integrated utilities. The old view held that integration was an obstacle to competition and the coming of energy markets would allow regulators to specialize in what they allegedly did well – controlling natural monopolies. The market could be left to do what regulators probably did poorly – to apply competitive pressure to produce and invest efficiently. The newer view holds that the continued existence of vertical integration is evidence of its efficiency. The fact that generation was technologically separable from other aspects of power delivery did not imply that it was economically desirable. Economists had a great deal to say about the efficient design of energy markets during the restructuring, but the design of utility organizations has been primarily a political question. In California the utilities' prime interests lay in recovering stranded costs and positioning themselves for post-transition competition. After they made the bargains that brought the PX, ISO, and divestiture, there were no parties interested in undoing the political compromise by attempting to make the case that continuing vertical integration was in reality efficient.

During the 2000-2001 crisis, energy prices in the California spot markets tracked short-term energy prices at other locations in the west quite closely. The major difference was that California's utilities had a far greater exposure to this market than utilities that remained integrated, and the CPUC did not allow them to use other risk management tools. Utilities elsewhere in the west would appear in the short-term markets as either buyers or sellers depending on the day's operating conditions, but California's would always be massive buyers. The state's disastrous transition was a failed gamble by utilities that for the next five years demand would not catch up with the state's largely unchanged generation capacity. At the peak of the crisis, state government signed long-term contracts for nearly of all of the power that its insolvent unities could not generate from resources that they still owned. A few weeks after the signing, supply and demand conditions changed and energy prices fell below those in the contracts, but now California's utilities were in effect reintegrated. Over three years its regulators were given two lessons on the hazards of thoughtless decisions about integration: a quick divestiture aggravated the effects of dependence on highly volatile energy markets, and a panic-driven reintegration through the state contracts brought very high but stable prices. These lessons about integration went either unlearned or misinterpreted, while new laws expand the scope of state activity in utility planning.

V. Transmission Operators

A. Inventing the ISO

1. FERC

Electricity is unique among restructured industries in its simultaneous revision of both market and governance institutions. (Michaels 1999) Robust wholesale markets require that buyers and sellers have access to a wide region, but access had historically been obstructed by both utilities and regulators. Utilities preferred monopolies in their service territories and external transactions only with other utilities, and prior to 1992 FERC had no powers to order them to transmit for eligible third parties. Regulated transmission rates also stood in the way. When two transmission-owning utilities traded power, a fictitious "contract path" between them would determine the allocation of transmission charges. In reality the power flowed everywhere in the region, but as long as transactions were few and excess transmission capacity was common they could neglect the consequences of loop flows. Regulators set transmission charges on an average cost basis, and principles of nondiscrimination treated utilities on the contract path symmetrically. If utility A sent power to utility C on a contract path that went through B, C would be expected to pay both A's and B's filed transmission charges. From a regional standpoint this was only a slight alteration in power flows, but under contract path ratemaking the cost of transmission over multiple systems was a barrier to the growth of markets.

In late 1995 FERC began to study open access transmission policy, and embodied its findings in Order 888 of 1996. (FERC 1996) It expressed the Commission's preference for ISOs that met certain standards of independence, but did not compel their formation. FERC would consider proposals for both nonprofit and for-profit ISOs, but stated that the latter could not be closely affiliated with generation. FERC next held technical conferences at which corporate utilities envisioned ISOs as regulated corporations, while public entities preferred the nonprofit form. MIT Economist Paul Joskow envisioned a nonprofit joint venture whose board of directors would contain representatives of utilities, non-utility generators, regulators, and "others representing the public interest."[65] The appropriate functions of an ISO were also debated, with Harvard's William Hogan favoring nodal transmission pricing and full integration with a PX. Some attendees were concerned that they were planning the details of an institution that had never before existed, and that once such an institution was in place it could not adjust to changes in technology and markets.[66]

2. <u>California</u>

At the same time FERC was formulating Order 888, the CPUC released its basic decision on restructuring in December 1995. (D.95-12-063) Virtually all interested parties, including competitive producers and traders, agreed with its plans for an ISO. They believed that if the utilities continued to operate transmission they would schedule flows on it to advantage themselves against competitors. The ISO would take no market positions and have no interests in load or generation. A separate institution, the Power Exchange, would administer the energy markets, and bilateral transactions outside the PX were possible for all transactors other than the utilities. The ISO would integrate PX and bilateral transactions and administer a zonal pricing system for transmission. The decision took no position on whether it should be a regulated corporation, a nonprofit, or a governmental operation. (D.95-12-063, 60)

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[65] "FERC Wrestles with Implementation,." Jan. 29, 1996. State regulators would not appear on boards, but many other interests would. The trade press (a transcript is unavailable) does not discuss the reasoning behind Joskow's choice of a nonprofit.

[66] "Most Industry Participants," Feb. 7, 1996.

After dominating the design of the PX and ISO, in mid-1996 California's utilities applied to FERC for market-based rates, by showing that those markets were sufficiently competitive that their prices would satisfy its "just and reasonable" legal standard. The PX and ISO would both be nonprofit institutions, governed by boards of interest group representatives.[67] Economists on all sides had much to say about their market designs and transmission pricing, but none questioned the institutional structures being proposed.[68] Only one economist testified on the ISO's actual independence and rules for its governance. The Sacramento Municipal Utility District retained University of Chicago professor Dennis Carlton to argue that transmission-owning utilities would dominate the ISO (their personnel were in some cases the only ones knowledgeable enough to operate it), and that they would use that knowledge to advantage their own generation. Acting as planners at the ISO, the utilities would not want to build transmission that would decrease the value of their generators, many of which were "must-run" units whose operation was at times required for reliability. Carlton also questioned the voting rules that required a two-thirds majority, since it would allow utilities to form coalitions with allies to veto proposals beneficial to a majority of the board.[69] Municipal utilities including Sacramento also protested that in the "collaborative" process to form the ISO and PX, the only parties allowed to vote were the three corporate utilities.[70]

Shortly after the ISO began operation, the President of the CPUC told a trade journal that the CPUC actually believed that transmission divestiture and the formation of a single transmission-only corporation would have been a superior alternative to ISOs. "Political reality," however, stood in the way because a divestiture would have been legally difficult and require

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[67] "California's Three Large," May 1, 1996. Above the PX and ISO would be a newly created Electricity Oversight Board, whose jurisdictional conflicts with FERC were generally resolved in the latter's favor and which ceased to have many meaningful functions as the market crisis grew.

[68] Della Valle (1997) gives a fuller discussion of the legal and financial issues in divestiture, as well as a taxonomy of the forms it might take.

[69] "FERC: Calif. Must Run vs. Market Power," Sept. 13, 1996. Must-run units would be a continuing problem for the ISO, even after the utilities agreed to mitigate the problem with contracts to regulate the price of their power. In 1997 the ISO governing board classified 14,500 MW (one-third of the state's power supply) as must-run, a figure which has since fallen. ("Most California," July 21, 1997, 11)

[70] "Various Parties Protest," (June 26, 1996), 1.

three to five years and extensive financing.[71] This episode further points up the difficulty of designing rational economic institutions in a political setting. At the time, there were no prospective transmission-only firms in existence to offer expert testimony favoring such a structure.[72] Ten years later, a few transmission-only companies exist, but they will be operating under ISOs whose governance is heavily influenced by the remaining integrated utilities.[73]

B. Cost-benefit Studies and Order 2000

Two years After the formation of ISOs in California and the northeast, only one more ISO had opened, in Texas. FERC's interest in regional coordination remained strong, but its legal ability to compel membership in RTOs is still in doubt. On December 17, 1999 the Commission issued Order 2000. It offered additional inducements to join RTOs. Still faced with resistance, FERC next proposed a set of regional RTOs, and in 2001 it commissioned a cost-benefit study of them and their markets. The study estimated that the RTO markets would create benefits in the form of lowered production costs with a present value of $40.9 billion between 2002 and 2021, approximately a 2 percent annual saving over their base case.[74] Critics quickly determined that the model's assumptions about technology, as opposed to markets, drove most of its results. 85 percent of the alleged benefits came from its assumptions about the increased efficiency of new generation. Some of the remainder was due to assumptions that reserve margins could decline

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[71] "California PUC's Conlan," (July 28, 1997, 10). Note that California's political reality became FERC's preferred institutional form. FERC, however, probably does not have the power to order divestitures.

[72] Enron Capital and Trade Resources, a marketer, sponsored testimony at the CPUC by Richard Tabors proposing a transmission-only entity. The research underlying that testimony appears in Fernando *et al* (1995).

[73] They include American Transmission Company in the midwest <http://www.atcllc.com/>; and Trans-Elect, which operates regional systems in Michigan and Canada and is prime contractor for the expansion of Path 15 between northern and southern California. <http://www.trans-elect.com>

[74] ICF Consulting (2002, 77). The assumed discount rate was 6.97 percent. Several other scenarios were posited, all of which provided annual benefits ranging from 0 to 3 percent.

from 15 to 13 percent, and that transmission transfer capability would increase by 5 percent per year at no cost. (Lenard 2002)

One of the most important flaws in this and most later studies was the lack of any description of the trading institutions that were being assumed, and how they might affect the calculation. The benefit estimate was the solution of a linear programming problem, derived from a model of least-cost dispatch rather than a model of the operating practices that might occur in actual markets. The study's authors determined that the cost of forming RTOs would be between $1 billion and $5.75 billion. (ICF Consulting 2002, 79) If 85 percent of their projected benefits are in fact due to improved generator efficiency, RTOs may not be worth forming. In practice these costs have been high and increasing. Lutzenhiser's (2004) recent collection of data shows that the operation and maintenance costs of all ISOs and RTOs have risen in every year since their opening. Between 2000 and 2003 California rose by approximately 35%, New York by 100%, and PJM by 250%. The corresponding figures per mwh were 23%, 73%, and 181%. All of these ISOs had initiated their basic market operations before or during 2000.[75] Their setup costs ranged from $250 million to $500 million. (Stagliano 2001, 23)

A substantial number of other studies have used methods similar to FERC's. In 1996 a group of pro-market organizations examined a least-cost dispatch and estimated up to a 40 percent saving. (Maloney *et al* 1996) The U.S. Energy Information Administration (1997) estimated savings of 8 to 15 percent from competitive markets, again on the basis of dispatch algorithms.[76] A number of others exist, most of little individual interest. Their complex modeling techniques and large data requirements make it extremely difficult to pinpoint the reasons of their differing results. (Clapp and McGrath 2002). Even if we accept the calculations as accurate, many of their treatments of economic efficiency are theoretically questionable. Often they identify

[75] Lutzenhiser (2004, 3-4). The total percentages were calculated from figures on a graph. Data are given for the per mwh costs, but these also include maintenance while the others are only "operating costs." In unpublished correspondence PJM has argued that Lutzenhiser's figures are too high since include extraordinary expenses in connection with expansion of membership that should not be included in operating costs.

[76] EIA (1997, ix). The report estimated that prices could fall by as much as 24 percent under conditions of "*intense* competition" with sellers aggressively cutting prices.

increased efficiency with decreased customer bills, but some (possibly much) of that decrease must be netted against the loss of wealth by generators, whose incomes will be lower. The only study that adequately accounts for the transfer is Wolfe's (2002) work on the proposed RTO West. She estimates a 2004 reduction in marginal costs of $1.3 billion, from which lowered generation revenues of $900 million must be subtracted. The report is also noteworthy because unlike others it analyzes the situation with and without a specific institutional innovation, the RTO's proposed locational pricing system for transmission.[77]

C. Profits, Voting, and Monitors

Orders 888 and 2000 state that FERC will consider applications by both nonprofit and profit-seeking ISOs or RTOs. The original ISO proposals (made at a FERC technical conference) by economists William Hogan and Paul Joskow envisioned a nonprofit organization with representative government. They said little about the difficulties in governance such an organization might actually encounter (and which California's ISO did see in 2000-2001). Neither they nor FERC gave noticeable weight to economist's findings of more efficient operations by profit-seeking firms in other industries that contained a mix of them and non-profit organizations (e.g. hospitals).[78] On the other side, supporters of non-profit organizations largely disregard the efficiency findings and conclude that a transco with even minimal interests in generation will act monopolistically. Michaels' (1999) work is the only one to examine the non-profit controversy in the light of recent developments in organizational and financial economics. His case for the efficiency of a transco is based on several applications of principal/agent theory and the economic theory of voting.

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[77] Wolfe (2002, vii). This report is also the only one of its kind that estimates the spillover benefits to other regions that will result from the changeover in RTO West's territory.

[78] A summary of research on for-profit and nonprofit institutions appears in Hansmann (1996). In one of many similar articles, lawyers Angle and Cannon (1998) assert in their text that for-profit institutions will watch costs more closely and be more innovative than nonprofits. The only authorities they cite are two FERC Commissioners, neither of whom was an economist.

Economists and political scientists have extensively analyzed rules for collective choice.[79] Their work has shown the innate imperfections of nearly all voting systems in aggregating individual preferences, and the general impossibility of controlling strategic voting. That work, however, has also shown that some decision-making mechanisms are superior to others in important ways, such as the ability of the person who sets the agenda to influence results by choosing a sequence of votes. The quality of the decisions that an ISO's governing board makes will be critical to the success of the markets it operates, but no experts on voting or committee structures provided input during proceedings on ISO designs. Michaels (1999) examines some properties of alternative voting mechanisms and shows that the constellation of interest groups on an ISO board may render it relatively vulnerable to manipulation by strategic voting. He also points out that a "nonprofit" ISO's books may show no profit, but the votes of its governors affect the wealth of the interests they represent. Some of California's difficulties in 2000-2001 stemmed from the growing inability of its ISO's governors to reach decisions, which ultimately led FERC to order a reconstitution of the board.[80]

Economists with an understanding of corporate organization and collective choice could have usefully contributed to the RTO debate in a third area. Order 2000 requires that all RTO applicants include a description of their proposed market monitoring institutions (MMIs). These institutions use market data to detect activities believed to be exercises of market power, have further powers of investigation, and are also charged with pointing out any flaws they might find in market design. Existing MMIs have produced numerous reports and testimonies of varying quality, a discussion of which is beyond the scope of this paper. MMIs are both political and economic institutions. They were not suggested by FERC or by consumer groups. Instead they were originally proposed by the California utilities as amendments to their PX and ISO applications after FERC ruled them ineligible for market-based rates. In some cases MMIs are staffed by RTO employees and in others they are appointed committees of external experts. Their functions are at least in part political. Economists often disagree over whether certain behavior is anticompetitive,

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[79] Buchanan and Tullock (1965), Riker (1962), Saari (1994)

[80] The courts very recently ruled that FERC does not have the power to alter the governance of utilities under its jurisdiction, which includes the ISO. California Independent System Operator v. FERC, 372 F.3d 395. (2004)

but every MMI report on record has been unanimous. (Michaels 2003). California's MMIs reported some scheduling practices of sellers as anticompetitive attempts to raise price by submitting bids that did not reflect their true demands. They made no similar reports about attempts by utilities to submit false schedules whose effect would be to lower prices.[81] In another vein, arbitrage between the day-ahead and real-time markets known as virtual bidding (simultaneous buy and sell orders in the two markets) is a generally desirable and efficient practice. PJM's monitors were not under pressure from utilities to keep prices artificially low, and they encouraged virtual bidding. California's monitors were under such pressure, understood that virtual trading would interfere with attempts to manipulate prices downward, and made the practice illegal. Economists have yet to perform an impartial study of the costs and benefits of alternative methods of monitoring the competitive behavior of markets. Had they done so, market monitoring might be less politicized than it is today.

D. Summary

Economists have provided significant input into the details of RTO market design, and their contributions have undoubtedly improved market performance.[82] Whether by accident or intent, their contributions to the design of RTOs and their governance were minimal. Over the past forty years there have been significant advances in the analysis of organizations, transaction costs, and collective choice that were directly applicable to the design of ISOs and RTOs. That new learning has convinced much of the economics profession that the design of institutions is as important as the design of markets themselves, and that economics offers insights that could not have been obtained from any other specialists. It might have been quite useful at the outset for economists to simply remind FERC and others that rational persons in nonprofit organizations will seek to advantage themselves just as they would in for-profit ones. Instead, much of U.S. electricity is now governed by organizations for which there are no precedents in any industrial

[81] In one of their reports the California PX's monitors went so far as to explain how utilities could modify their bidding strategies to improve their chances of success in lowering market prices.

[82] For a summary, see Wilson (2002).

context as important as electricity. Where those organizations have been stressed, as in California, they have failed to produce coherent policy.

VI. Summary and Conclusions

The analysis of vertical integration became an integral part of economic theory only quite recently. As this happened, economists came to understand that it often had desirable effects on economic efficiency because it reduced the costs of coordinating economic activities relative to the alternatives of markets or contracts. Vertical integration became a common organizational form in electricity due to technological requirements that supply equal demand at all times everywhere on a network. In addition, the industry's specialized plants were less vulnerable to opportunistic conduct if they were owned by the same organization rather than under contract.

The old economic view saw vertical integration as a tool that a monopolist could use to extract profit from competitive activities. Modern reasoning discredited that argument in unregulated situations, but it might still apply to regulated ones. In the 1970s and 1980s lawyers and economists created a literature that made the case for vertical de-integration of utilities by simply assuming that integration served no useful function. If true, the separation of generation from transmission could bring the benefits of competition at no cost in efficiency. Econometric research proved that this was not so. Studies in the 1980s and 1990s almost invariably concluded that vertical integration produced efficiencies that would be lost in a breakup. These economies of integration applied to both the generation-transmission interface and to the ownership of generators and fuel supplies.

This scholarship was almost totally forgotten as California and other states began to restructure their power industries in the mid-1990s. A few economists argued that there were both costs and benefits to vertical integration and a rule of reason was needed. Many others simply chose to assert that integration was worse than useless – if not constrained, transmission monopolists integrated into power production could destroy the benefits of competitive generation.

The ISO came into being as a midway point between full integration and full deintegration. In California it was supplemented by divestiture. Generators that would often set market prices at the PX and ISO were sold off without contracts that would have given the utilities security of supply and prices. Two years after California's markets began operation, the growing imbalance of supply and demand combined with a constellation of other forces to bring about a pricing crisis. In its aftermath, utilities and regulators are investigating the possibilities for re-verticalizing utilities, possibly with a separation of core and non-core customers.

The ISO and RTO were envisioned as institutions that could operate and price regional power flows efficiently, and also administer markets for portions of that power. A series of questionable quantitative studies estimated that large benefits would be forthcoming, but the studies were calculations of optimum dispatch rather than projections of the behavior of markets. Numerous interested parties were concerned about discrimination by transmission owners, but the ISO concept was formulated without an adequate appreciation of the economic incentives of the institution's managers and clients. Some economic experts displayed the same naivete as non-economists in their expectation that nonprofit organizations would operate benignly and efficiently. There was never a real debate over whether RTOs should be for-profit or non-profit, in large part because the nonprofit ISO was a politically expedient compromise rather than a thoughtfully planned institution. As economists would have predicted, ISOs governed by representatives of interest groups have at times had difficulty in reaching coherent decisions and have instituted highly imperfect and politicized monitoring procedures.

A few critics look at California and urge a return to fully regulated, self-sufficient utilities, but over the rest of the nation most observers probably agree that on balance the results of restructuring and partial deregulation have been positive. If economists and others had better understood the significance of vertical integration in the industry, restructuring would have produced better policies and better institutions. Contracts and integration are substitutes, but California left its utilities to divest their plants and rely on short-term markets without any hedging possibilities. Markets have virtues, but the question of whether or not to rely on them is really a question about the costs and benefits of vertical integration. Economists have a great deal of useful knowledge in this area, but they have played at best a peripheral role in the design of the institutions that will determine the industry's future.

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TABLE 1

SUMMARY OF VERTICAL INTEGRATION STUDIES

Auth/date	Sample	Method	Findings	Comments
Henderson (1985)	160 U.S. utilities, most vertically integrated, 1970	Marginal cost of steam, hydro, and purchased power is used as energy transfer price in estimate of translog cost function that includes labor, capital and energy, tests coefficients for separability	Estimate of model that excludes produced power yields downwardly biased estimate of scale economies, concludes costs are not separable due to vertical economies	Only addresses effect of generation costs on transmission/distri-bution and not reverse
Roberts (1986)	65 U.S. electric-only utilities, no holding company units, 1978	Estimate translog cost function for distribution to examine effects of territory size and density, test for separability of distribution from generation and transmission	Coefficient restrictions implied by separability of distribution and generation/transmission costs are rejected. (Author notes this in passing since study was intended to estimate effects of service area density.)	Article primarily about effects of territorial size and customer density on distribution cost, Does not contain information for numerical estimate of integration effect
Eftekhari (1989)	61 U.S. non-nuclear utilities, 1986	Estimate multi-output translog cost function with labor, capital, fuel inputs	Finds very few economies of scale but substantial diseconomies of joint production, concludes that smaller, vertically de-integrated utilities would be more efficient	Variables said to measure output include number of ultimate customers, fraction of generated power they buy, and statistically unreliable measure of interchange
Kaserman & Mayo (1991)	74 U.S. electric-only utilities, vertically integrated, 1981	Estimate quadratic multiproduct cost function that allows tests of economies of scope between generation and transmission / distribution	Finds 12 % cost savings from vertical integration for average-size utilities, extremely small utilities are the only ones not to benefit from it.	Estimate of scope economies requires use of a sample containing some generation-only and distribution-only utilities

TABLE 1 (Cont.)

Gilsdorf (1995)	72 U.S. vertically integrated utilities, 1985	Estimate translog cost function for generation and transmission-distribution [combined], with fuel, capital, and labor costs, also customer density, capacity utilization, and percent of sales to ultimate customers	Performs Evans-Heckman subadditivity test for those utilities whose location on estimated function has normal economic properties [20 were excluded]. Fails to reject null hypothesis of additivity for any utilities. Also finds stage-specific economies of scale	Author notes that failure to pass subadditivity test need not support a divestiture policy, since there may be economies of scope between stages without subadditivity
Lee (1995)	70 U.S. "electric utility firms," 1990	Estimates translog production functions for generation, transmission, distribution, also estimates final output as function of all variables.	Tests for complete separability of generation, transmission, and distribution, and for separability of generation and distribution alone. All null hypotheses of no separability rejected.	Also estimates efficiency losses from various forms of de-integration between 4.1 and 18.6 percent
Hayashi et al (1997)	50 U.S. electric utilities, annual data 1983 - 1987	Estimates translog cost functions for generation and transmission-distribution, and for total	Rejects null hypothesis of cost separability, also finds that both large and small firms operate in range of scale economies in generation	Estimates economies of vertical integration for firms ranging from 9.2 percent to 24.2 percent
Thompson (1997)	83 - 85 U.S. "all major investor-owned utilities" 1977, 1982, 1987, 1992	Estimates translog cost function with input prices and number of customers, territory size, and sales at different voltages	Rejects separability of either distribution or power supply from remaining utility services over entire time period	Finds that in later years the difference between unrestricted and restricted estimates is smaller, but remains significant.

TABLE 1 (Cont.)

Goto & Nemoto (1999)	9 Japanese vertically integrated electric utilities, annual data 1980 - 1997	Estimate shadow cost and input demands from Symmetric Generalized McFadden (SGM) function, inputs include purchased power. Tests for effect of generation capital on transmission-distribution costs and estimates allocative distortions.	Finds that generation enters transmission-distribution cost function positively in unintegrated case, concludes that unintegrated costs are higher because of over-investment in generation relative to integrated firms	Method also allows estimation of allocative distortions in input mix, finds that average percentage that costs could be reduced over sample period ranges from 0.13 % to 2.97 % for individual utilities
Kwoka (2002)	147 U.S. corporate utilities, some unintegrated 1989	Estimate quadratic cost function in generation and distribution to test for economies of scope	Negative interaction term between generation and distribution cost is evidence of complementarity. Comparison with standalone costs indicates that only very small utilities show diseconomies of vertical integration	Concludes that most utilities have chosen to operate where they can best realize these economies, with generation close to but less than distribution output
Nemoto & Goto (2004)	9 vertically integrated Japanese utilities, annual data 1980 - 199	Estimate SGM for variable and fixed costs on assumption that capital is incompletely adjusted to optimum	Compares variable costs for integrated and standalone production of stages, finds average economies of integration over period for individual companies range from 4.5 % to 13.9 %	Authors note questions about their additive allocation of capital between stages, state need to verify that observed cost structures are sufficient for natural monopoly