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IPU BIBLIOGRAPHY: MARKET POWER AND PERFORMANCE

ADDENDUM TO THE 2006 PERFORMANCE REVIEW OF ELECTRIC POWER MARKETS¹

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- ▶ Market performance
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MARKET PERFORMANCE

- ▢ Blumsack, Seth. "Market Power and Mitigation in Deregulated Electricity Markets" (March 18, 2004).
- ▢ Hogan, William W.. "Local Market Power Mitigation: Comments." Technical Conference on Compensation for Generating Units Subject to Local Market Power Mitigation In Bid-Based Markets PJM Interconnection, L.L.C. Docket Nos. PL04-2-000, EL03-236-000. Submitted to the Federal Energy Regulatory Commission, Washington, D.C. (February 4, 2004).
- ▢ Moody, Diane C. "Ten years of experience with deregulating US power markets." *Utilities Policy* 12, 3 (September 2004): 127-137.

Advocates of deregulating electricity markets claimed that allowing competition would benefit consumers by increasing efficiency and reducing costs. They viewed electricity as a commodity much like any other, and overlooked the ways in which electricity's many distinct features hinder the development of competitive market structures. While competitive features were introduced into electricity markets in the last 10 years, the necessary elements for the market structure of competition—large number of sellers, ease of entry, and transparency of information—are still not in place.

- ▢ [Murillo-Sanchez, Carlos E., Ray D. Zimmerman, and Robert J. Thomas. "Kirchhoff vs. Competitive Electricity Markets: A Few Examples" \(2001\).](#)

¹ This bibliography was prepared as an addendum to the *2006 Performance Review of Electric Power Markets* conducted for the Virginia State Corporation Commission (August 27, 2006). The analysis, views, and opinions are those of the authors.

Electric power is often regarded as a homogeneous commodity due to the ubiquity of the transmission grid. This paper, however, presents a collection of cases in which the physical laws governing network flows can have anomalous and unexpected market implications. For example, reactive power requirements can affect optimal unit commitment and impact real power prices in otherwise competitive markets. Network topology and constraint interactions can result in other unwelcome market phenomena, such as large price differentials within a congestion zone, nodal prices well above the highest offer and "cascading market power".

- ▢ Ramos-Real, Francisco Javier. "Cost Functions and the Electric Utility Industry. A Contribution to the Debate on Deregulation." *Energy Policy* 33, 1 (January 2005): 69-87.

This study analyses the main articles that estimate cost functions in the electricity utility industry with a view to studying of the initial arguments for proposing competition and vertical disintegration. The works reviewed here, in general terms, confirm the initial arguments in favor of the deregulation process, mainly, the exhaustion of scale economies for moderate size firms in generation and the condition of natural monopoly for transmission and distribution. However, the savings obtained from undertaking different activities together should be kept in mind when restructuring the sector. On the other hand, the improvements in productivity deriving from the reforms have not translated into reductions in the price of electricity in many countries. These last two results suggest the need for appropriate market regulation for the deregulation process to translate into an improvement in how the sector works and into benefits for consumers. There is still insufficient empirical literature on these issues due to the fact that the process is still ongoing in many countries and more time will have to transpire before sufficient data is available.

- ▢ [U.S. Department of Energy, Energy Information Administration. "Electricity Transmission in a Restructured Industry: Data Needs for Public Policy Analysis" DOE/EIA-0639 \(December 2004\).](#)

- ▢ [Wolak, Frank. "Lessons from International Experience with Electricity Market Monitoring." CSEM Working Paper 134 \(June 2004\).](#)

This paper first describes those features of the electricity supply industry that make a prospective market monitoring process essential to a well-functioning wholesale market. Some of these features are shared with the securities industry, although the technology of electricity production and delivery make a reliable transmission network a necessary condition for an efficient wholesale market. These features of the electricity supply industry also make antitrust or competition law alone an inadequate foundation for an electricity market monitoring process. This paper provides examples of both the successes and failures of market monitoring from several international markets. More than ten years of experience with the electricity industry re-structuring process has demonstrated that market failures are more likely and substantially more harmful to consumers than other market failures because of how electricity is produced and delivered and the crucial role it plays in the modern economy. Wholesale market meltdowns of varying magnitudes and durations have occurred in electricity markets around the world, and many of them could have been prevented if a prospective market monitoring process backed by the prevailing regulatory authority had been in place at the start of the market.

- ▢ [Wolak, Frank A., Brad Barber, James Bushnell, and Benjamin F. Hobbs. "Market Power Mitigation under Locational Marginal Pricing" \(November 24, 2004\).](#)

IMPACTS OF RESTRUCTURING

- Blumsack, Seth A. Jay Apt, and Lester B. Lave. "Lessons from the Failure of U.S. Electricity Restructuring." *The Electricity Journal* 19, 2 (March, 2006): 15-32.

Blind faith is unlikely to produce a free market that is competitive. Substituting markets for traditional regulation is only one choice among many policy instruments to achieve a goal of lower prices; such substitution should not be in itself a goal.

- Goulding, A.J., Carlos Rufin, Gregory Swinand. "The Role of Vibrant Retail Electricity Markets in Assuring that Wholesale Power Markets Operate Effectively." *The Electricity Journal* 12, 10 (December, 1999): 61-73.

Barriers to competitive supplier entry such as California's wholesale-price pass-through model can provide an almost insurmountable barrier to effective retail competition. The telecommunications, airline, and software industries provide lessons—positive and negative—on how creating competitive wholesale markets is insufficient to bring the benefits of competition to smaller consumers.

- [Kwoka, John. "Restructuring the U.S. Electric Power Sector: A Review of Recent Studies." Report Prepared for the American Public Power Association \(November 2006\).](#)

This report . . . concludes that the methodologies used in these studies consistently fall short of the standards for good economic research. In addition, most of these studies fail to fully address the effects of restructuring. These deficiencies call into question the conclusions reached by existing studies of restructuring. In particular, despite much advocacy, there is no reliable and convincing evidence that consumers are better off as a result of restructuring of the U.S. electric power industry.

- Morrison, Jay A. "The Clash of Industry Visions." *The Electricity Journal* 18, 1 (January - February, 2005): 14-30.

Not everyone shares the Federal Energy Regulatory Commission's belief that consumers can best be served by bid-based, security-constrained spot markets operated in conjunction with a market-based locational marginal pricing transmission congestion management system. FERC won't be able to develop a consistent transmission policy that benefits consumers until it enunciates a vision of the industry that can attract industry and political support. One way to do so is by returning to the open-access vision of the industry implicit in the Energy Policy Act (EPAAct) of 1992 and Commission Order Nos. 888 and 889.

- Newbery, David M. and Michael G. Pollitt. "The Restructuring and Privatisation of Britain's CEGB—Was It Worth It?" *Journal of Industrial Economics* 45, 3 (September 1997): 269-303.

We report a social cost-benefit analysis of the privatization and restructuring of the Central Electricity Generating Board which generated and transmitted all public electricity in England and Wales until 1990. The main benefits came from generator efficiency gains, switching from nuclear power, and lower emissions. The main costs came from higher prices for imported French electricity, the cost of restructuring and premature investment in new gas-fired generating plant. Our central estimate is a permanent cost reduction of 5% per year, equivalent to an extra 40% return on assets. Consumers and government lose, and producers gain more than the cost reduction.

- Percebois, Jacques and Philip Wright. "Electricity Consumers Under the State and the Private Sector: Comparing the Price Performance of the French and UK Electricity Industries 1990–2000." *Utilities Policy* 10, 3-4 (September - December, 2001): 167-179.

Particularly because a preoccupation with process has tended to dominate the debate about electricity privatization and liberalization, this paper focuses on price outcomes by comparing the relative price performance of the French and UK electricity industries between 1990 and 2000. The main conclusion is that in 1990 the state-owned French electricity industry was performing better for most consumers than the state-owned UK industry, and a decade later it was still doing so with respect to the privately-owned UK industry. While this conclusion could be qualified by saying that, heavily prompted or assisted by the Regulator, the UK privately-owned industry has shown itself capable of achieving faster reductions in prices to close the gap between itself and the French, this achievement has been concentrated in the industrial market and even there the very significant gains were mainly restricted to the very largest consumers. In the context of the European Union the UK is shown to have performed relatively poorly for the smallest domestic consumers and, while both countries did much better in the rankings of industrial prices, they were still a long way behind the top performers.

- Spinner, Howard M.. "A Response to Two Recent Studies that Purport to Calculate Electric Utility Restructuring Benefits Captured by Consumers." *The Electricity Journal* 19, 1 (January - February, 2006): 42-47.

Recent studies by Global Energy Decisions and Cambridge Energy Research Associates offered high "headline impact" in finding that wholesale electric competition is fulfilling its promises and restructuring is benefiting consumers to the tune of billions of dollars. But both studies share a fundamental problem tied to the fact that portions of those "savings" to consumers accrue from losses suffered by the competitive generation sector.

- Zarnikau, Jay and Doug Whitworth. "Has electric utility restructuring led to lower electricity prices for residential consumers in Texas?" *Energy Policy* 34, 15 (October, 2006): 2191-2200.

This paper analyzes the determination of residential electricity prices in the competitive Electric Reliability Council of Texas (ERCOT) market. This analysis suggests that electricity restructuring in Texas has not yet resulted in lower prices for the majority of residential energy consumers in areas open to competition. Contrary to common expectations, residential electricity costs for consumers at a typical (1000kWh per month) consumption level have increased at a greater rate in the areas of Texas offering retail choice than in the areas of the State where retail competition has not been introduced.

OLIGOPOLY

- Blumsack, Seth, Dmitri Perekhodtsev, and Lester B. Lave. "Market Power in Deregulated Wholesale Electricity Markets: Issues in Measurement and the Cost of Mitigation." *Electricity Journal* (November 2002): 11-24.

An analysis of three recently deregulated markets California, PJM, and New York finds that none of them can be regarded as highly competitive, contrary to what conventional measures of market power indicate. Auctions for generation are unlikely to be competitive and costly steps will be needed to mitigate market power, likely eroding any benefits from increased operating efficiency in deregulated markets. Thus, FERC and state legislators need to reexamine the desirability of deregulating the generation portion of the industry.

- Borenstein, Severin, James Bushnell, and Frank Wolak. "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market." *American Economic Review* 92:5 (2002): 1376-1405.

We present a method for decomposing wholesale electricity payments into production costs, inframarginal competitive rents, and payments resulting from the exercise of market power. Using data from June 1998 to October 2000 in California, we find significant departures from competitive pricing during the high-demand summer months and near-competitive pricing during the lower-demand months of the first two years. In summer 2000, wholesale electricity expenditures were \$8.98 billion up from \$2.04 billion in summer 1999. We find that 21

percent of this increase was due to production costs, 20 percent to competitive rents, and 59 percent to market power.

- [Bushnell, Jim. "Looking for Trouble: Competition Policy in the U.S. Electricity Industry." CSEM Working Paper 109 \(April 2003\).](#)

In the aftermath of the California energy crisis, there has been a shift in the focus of electricity regulators away from the fostering of a competitive market structure and towards the application of regulations to specific market outcomes. Such a focus stands in marked contrast to the general principles governing competition policies in other industries. This shift is in part influenced by the clear failure of earlier attempts to establish a competitive market structure in California. But was this a failure of the policy, or of the tools that were used to implement it? In this chapter, I describe the tests historically used by regulators as screens for the potential abuse of market power by suppliers.

More advanced methods, such as models of oligopoly competition, can potentially provide a much better understanding of the competitive outlook for a market. However, much uncertainty surrounds the development and application of such models. I apply an oligopoly model of the California market to actual market data to test the ability of such models to recreate true market outcomes. I also explore the potential impact of an alternative plan for the divestiture of California's thermal generation units. The results indicate that a more substantial, but still plausible, reduction in supplier concentration would have saved consumers nearly \$2 Billion during the summer of 2000.

- [Bushnell, James, Christopher Knittel, and Frank Wolak. "Estimating the Opportunities for Market power in a Deregulated Wisconsin Electricity Market."](#)
- "Do not Assume That Real Competition Exists in U.S. Electric Industry, APPA Tells Task Force." *Public Power Weekly* (November 28, 2005).
- Federal Trade Commission. *In The Matter of Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities, Recovery of Stranded Costs by Public Utilities and Transmitting Utilities; Proposed Rulemaking and Supplemental Notice of Proposed Rulemaking Docket Nos. RM95-8-000 & RM94-7-001 Comment of the Staff of the Bureau of Economics of the Federal Trade Commission, August 7, 1995.*
- Haas, R. and H. Auer. "The Prerequisites for Effective Competition in Restructured Wholesale Electricity Markets." *Energy* 31, 6-7 (May - June, 2006): 857-864.
- Lave, Lester B., Jay Apt, Seth Blumsack. "Rethinking Electricity Deregulation." *The Electricity Journal* 17, 8 (October, 2004): 11-26.

Proponents of free markets for electricity assert that minor fixes to the California market and to FERC's proposed Standard Market Design would generate lower prices. We disagree. Designing a competitive market that remedies the problems seen in California and other restructured markets is difficult; emulating even good ISOs like PJM will not do the job. Each one of the problems can be overcome, but the costs of doing so might make full deregulation unattractive.

- [Mansur, Erin T. "Environmental Regulation in Oligopoly Markets: A Study of Electricity Restructuring." PWP-088 \(April, 2004\).](#)

In an oligopoly market subject to environmental regulation through tradable pollution permits, polluters' output decisions affect the price of polluting. With a pollution tax, this feedback effect is absent. In a permit regime, I

show that the feedback effect increases strategic firms' production and improves welfare. I empirically test the environmental implications of oligopoly behavior in the Pennsylvania, New Jersey, and Maryland electricity market. Air pollution fell substantially during 1999, the year in which both electricity restructuring and a tradable permit system took effect. Surprisingly, I show that 33-42 percent of the emissions reductions resulted from strategic behavior in the electricity market. Simulations suggest that welfare loss would have been seven percent greater under a tax than with tradable permits.

- [Mount, T.D., W.D. Schulze, R.J. Thomas, and R.D. Zimmerman. "Testing the Performance of Uniform Price and Discriminative Auctions" \(July 2001\).](#)

The high prices that occurred in southern California since the Summer, 2000 led to a substantial amount of regulatory and political intervention. Price caps were lowered and the Federal Energy Regulatory Commission (FERC) proposed that a new type of "soft cap" auction should be adopted. This auction combines a standard uniform price auction with a discriminative auction for offers higher than a specified level (\$150/MWh). Nevertheless, there is little available evidence to show that this new auction works well, or guarantees lower average prices. The objective of this paper is to provide some experimental evidence about the relative performance of different types of auctions for electricity markets. The experiments involved engineering and economic graduate students at Cornell University and the University of Illinois, and regulators in the New York State Department of Public Service. These individuals represent generators in a "smart" market, POWERWEB. This market replicates the physical constraints of meeting loads in an electrical grid. The first part of this paper describes how the high price volatility observed in many electricity markets can be replicated. The key features are 1) load is stochastic, 2) incentives are provided to withhold capacity from the market, and 3) the price is determined by a uniform (last accepted offer) price auction. The results with six identical generators in the auction show 1) price spikes are common, and 2) average prices are higher than competitive levels. This confirms the belief that electricity markets with totally inelastic demand need more participants than typical markets to ensure competitive prices.

The second part of this paper describes experiments using four different types of auctions. In a "smart" market, the total cost of meeting load is minimized, subject to operating constraints, in all cases. The four auctions are 1) a uniform price auction with price inelastic load, 2) a uniform price auction with price-responsive load, 3) a discriminative auction in which generators are paid their actual offers instead of a uniform clearing price (commonly, and incorrectly, called pay-as-bid), and 4) a "soft-cap" auction combining a uniform price and a discriminative auction.

The main result for all three groups of participants shows that both the uniform price auction (1) and the discriminative auction (3) produce average prices fifty percent above competitive levels. However, the prices for the uniform price auction are more volatile with many price spikes. The soft-cap auction (4) has price characteristics similar to the discriminative auction. In contrast, the uniform price auction with price-responsive load (2) has lower average prices (about thirty percent above competitive levels). The lower price volatility associated with the discriminative auction and the soft-cap auction is caused by the flatter offer curves in these auctions. However, this flat shape is likely to undermine the effectiveness of demand conservation as a way to reduce average prices. The uniform price auction with price-responsive load is the best among the four auctions tested, because it produces the lowest average price and has relatively low price volatility.

- Thomas, Steve. "The British Model in Britain: Failing Slowly." *Energy Policy* 34, 5 (March, 2006): 583-600.

In 1990, Britain reorganized its electricity industry to run on competitive lines. The British reforms are widely regarded as successful and the model used provides the basis for reforms of electricity industries worldwide. The main reason for this perception of success is major reductions in the real price of electricity with no reduction in service quality. This paper examines whether the reputation of the British reforms is justified. It concludes that the reputation is not justified and that serious fundamental problems are beginning to emerge.

The central question is: have the British reforms resulted in the creation of efficient wholesale and retail markets? On this criterion, the reforms have failed. The wholesale market is dominated by obscure long-term contracts, privileged access to the market and self-dealing within integrated generator/retailers, leaving the spot markets with minimal liquidity and unreliable prices. The failure to develop an efficient wholesale market places the onus on consumers to impose competitive forces on electricity companies by switching regularly. Small consumers will not do this and they are paying too much for their power. For the future, there is a serious risk that the electricity industry will become a weakly regulated oligopoly with a veneer of competition.

STRATEGIC BIDDING

- [Bushnell, James, Mansur, Erin T. and Saravia, Celeste. "Vertical Arrangements, Market Structure, and Competition: An Analysis of Restructured U.S. Electricity Markets." Yale SOM Working Paper No. ES-40 \(February 15, 2005\).](#)

This paper examines the relative importance of horizontal market structure, auction design, and vertical arrangements in explaining electricity prices. We define vertical arrangements as either vertical integration or long term contracts whereby retail prices are determined prior to wholesale prices. This is generally the case in electricity markets. These ex ante retail price commitments mean that a producer has effectively entered into a forward contract when it takes on retail customers. The integrated firm has less incentive to raise wholesale prices when its sale price is constrained. For three restructured wholesale electricity markets, we simulate two sets of prices that define the bounds on static oligopoly equilibria. Our findings suggest that vertical arrangements dramatically affect estimated market outcomes. Simulated prices that assume Cournot behavior but ignore this vertical scope vastly exceed observed prices. After accounting for the arrangements, performance is similar to Cournot in each market. Our results indicate that auction design has done little to limit strategic behavior and that horizontal market structure accurately predicts market performance only when vertical structure is also taken into account.

- DeMarco, Christopher L. "Strategic Behavior in Electric Generation Markets via Dynamic Governor Control Design." *Decision Support Systems (Special Issue)* 24, 3-4 (January, 1999): 251-258.
- Hobbs, Benjamin F. and Fieke A.M. Rijkers. "[Strategic Generation With Conjectured Transmission Price Responses in a Mixed Transmission Pricing System—Part I: Formulation.](#)" *IEEE Transactions on Power Systems* 19, 2 (May 2004).

The conjectured supply function (CSF) model calculates an oligopolistic equilibrium among competing generating companies (GenCos), presuming that GenCos anticipate that rival firms will react to price increases by expanding their sales at an assumed rate. The CSF model is generalized here to include each generator's conjectures concerning how the price of transmission services (point-to-point service and constrained interfaces) will be affected by the amount of those services that the generator demands. This generalization reflects the market reality that large producers will anticipate that they can favorably affect transmission prices by their actions. The model simulates oligopolistic competition among generators while simultaneously representing a mixed transmission pricing system. This mixed system includes fixed transmission tariffs, congestion-based pricing of physical transmission constraints (represented as a linearized dc load flow), and auctions of interface capacity in a path-based pricing system. Pricing inefficiencies, such as export fees and no credit for counterflows, can be simulated. The model is formulated as a linear mixed complementarity problem, which enables very large market models to be solved. In the second paper of this two-paper series, the capabilities of the model are illustrated with an application to northwest Europe, where transmission pricing is based on such a me/spl acute/lange of approaches.

- [Hobbs, Benjamin F., Fieke A.M. Rijkers, and Adrian F. Walsh. "Strategic Generation With Conjectured Transmission Price Responses in a Mixed Transmission Pricing System—Part II: Application." *IEEE Transactions on Power Systems* 19, 2 \(May 2004\).](#)

The conjectured transmission price response model presented in the first of this two-paper series considers the expectations of oligopolistic generators regarding how demands for transmission services affect the prices of those services. Here, the model is applied to northwest Europe, simulating a mixed transmission pricing system including export fees, a path-based auction system for between-country interfaces, and implicit congestion-based pricing of internal country constraints. The path-based system does not give credit for counterflows when calculating export capability. The application shows that this no-netting policy can exacerbate the economic inefficiencies caused by oligopolistic pricing by generators. The application also illustrates the effects of different generator conjectures regarding rival supply responses and transmission prices. If generators anticipate that their increased demand for transmission services will increase transmission prices, then competitive intensity diminishes and energy prices rise. In the example here, the effect of this anticipation is to double the price increase that results from oligopolistic (Cournot) competition among generators.

- Krapels, Edward N. and Paul Flemming. "Impacts of the PJM RTO Expansion." A report prepared for PJM by Energy Security Analysis, Inc. (November 2005).
- Oh, Hyung Seon, Robert J. Thomas, Bernard C. Leiseutre, and Timothy D. Mount. "A Method for Classifying Offer Strategies Observed in an Electricity Market." *Decision Support Systems* 40 (2005): 449– 460.

The idea that large-scale generating units will operate at marginal cost when given the ability to offer their power for sale in a uniform price auction is at best wishful thinking. In fact, both real and experimental data show that the more uncertainty a supplier faces (e.g., load uncertainty, uncertainty of other suppliers, etc.), the more they will hedge their profits through higher than marginal cost offers and through withholding units if permitted. This makes predicting unit commitment and dispatch ahead of time difficult. This paper explores characteristics of software agents that were designed based on the outcome of human subject experiments on a uniform price auction with stochastic load. The agent behavior is compared to the behavior of the subjects. Both subject and agent behavior is classified based on the data. Differences and similarities are noted and explained. Based on the result of the simulation, a model was suggested to explain an offer submitted in deregulated markets based on double layer diffusion.

- Weaver, Jacqueline Lang. "Can Energy Markets be Trusted? The Effect of the Rise and Fall of Enron on Energy Markets" *Houston Business & Tax Law Journal* 4,1 (2004).

"Greenspan Says Enron Cure Is In Market, Not Regulation." ... Because the energy market in California is not self-enclosed, price spikes spread to other western states on the interconnected grid. ... Once the trading documents were made public, speculation began about the link between California's energy crisis and Enron's bankruptcy. ... The gaming tactics revealed by the release of the Enron memos in May 2002 were those of a trader, not an electricity generator. ... So, the question is: Can we trust government to intervene and design restructuring rules that allow competition, consumer choice, and fair and reasonable rates to co-exist in a hybrid system that is more regulated (albeit differently regulated) than the traditional utility model? Can market-based rates co-exist with price caps that have become a rather permanent part of the regulatory landscape of deregulation? Can regulators stay one step ahead of market participants who, under a competitive regime, will naturally seek to test loopholes in market protocols to maximize profits--in ways that consumers will consider fundamentally unfair? In competitive electricity markets, participants can exploit legal loopholes or use market power to make millions of dollars in profits in a very short time period.

- Wolak, Frank A. "Measuring Unilateral Market Power in Wholesale Electricity Markets: The California Market, 1998-2000." *American Economic Review* 83, 2 (May 2003): 425-430.

This article discusses measurement of the unilateral incentives of the largest electricity suppliers in California. The incentives influenced how the suppliers had to exercise market power in the state's wholesale market during the four-month period from June 1-September 30 of 1998, 1999 and 2000. Measurement of firm-level market power; Empirical implementation and results; Conclusions and directions for future research.

- Wolfram, Catherine D. "[Strategic bidding in a multiunit auction: an empirical analysis of bids to supply electricity in England and Wales.](#)" *RAND Journal of Economics* 29, 4 (Winter 1998): 703-725

I consider bidding behavior in the daily electricity auction in England and Wales. Theoretical work on uniform-price multiunit procurement auctions suggests that bidders offering more than one unit have an incentive to increase their bids at high quantities. If a bid sets a high equilibrium price, it applies to all inframarginal units. I find evidence of strategic bid increases in the electricity auctions. First, plants that are likely to be used after other plants are already operating bid more. Second, the larger supplier submits higher bids for similar plants. Last, bids for a given plant are slightly higher on days when more of the capacity that is typically inframarginal to that plant is available.

- Younes, Ziad and Marija Ilic. "Generation Strategies for Gaming Transmission Constraints: Will the Deregulated Electric Power Market be an Oligopoly?" *Decision Support Systems* 24, 3-4 (January 1999): 207-222.

Constrained transmission lines are known to be able to economically isolate submarkets from the competition of players located elsewhere on the network. This paper examines the type of oligopolistic competition that is likely to take place in these submarkets. It shows, using simple models, how static or intertemporal Nash equilibria can arise in a framework of price or supply function competitions, found to be more realistic than Cournot models in the particular case of short-term competition in the electric power market. This paper shows also how transmission constraints can play a direct role in the outcome of the oligopolistic competition and encourage strategic behavior by the generators. Transmission lines that would not be constrained if the players did not know of their thermal limits may be strategically driven to operate at these limits in order to maximize the profits of the players who have market power, leaving the others to cope with the consequences of such behavior.

WITHHOLDING

- Borenstein, Severin, James Bushnell, and Steven Stoff. "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry." *Rand Journal of Economics* 31, 2 (Summer 2000): 294-325.

In an unregulated electricity generation market, the capacity of transmission lines will determine the degree to which generators in different locations compete with one another. We show, however, that there may be no relationship between the effect of a transmission line in spurring competition and the actual electricity that flows on the line in equilibrium. We also demonstrate that limited transmission capacity can give a firm the incentive to restrict its output in order to congest transmission into its area of dominance. As a result, relatively small investments in transmission may yield surprisingly large payoffs in terms of increased competition. We demonstrate these effects in the context of the deregulated California electricity market.

- [Dechenaux, Emmanuel and Dan Kovenock. "Tacit Collusion and Capacity Withholding in Repeated Uniform Price Auctions" \(March 1, 2005\).](#)

This paper contributes to the study of tacit collusion by analyzing infinitely repeated multiunit uniform price auctions in a symmetric oligopoly with capacity constrained firms. Under both the Market Clearing and Maximum Accepted price rules of determining the uniform price, we show that when each firm sets a price-quantity pair specifying the firm's minimum acceptable price and the maximum quantity the firm is willing to sell at this price,

there exists a range of discount factors for which the monopoly outcome with equal sharing is sustainable in the uniform price auction, but not in the corresponding discriminatory auction. Moreover, capacity withholding may be necessary to sustain this outcome. We extend these results to the case where firms may set bids that are arbitrary step functions of price-quantity pairs with any finite number of price steps. Surprisingly, under the Maximum Accepted Price rule, firms need employ no more than two price steps to minimize the value of the discount factor above which the perfectly collusive outcome with equal sharing is sustainable on a stationary path. Under the Market Clearing Price rule, only one step is required. That is, within the class of step bidding functions with a finite number of steps, maximal collusion is attained with simple price-quantity strategies exhibiting capacity withholding.

- Joskow, Paul and Edward Kahn. "A Quantitative Analysis of Pricing Behavior in California's Wholesale Electricity Market During Summer 2000." *Energy Journal* 23, 4 (2002): 1–35.

During the Summer of 2000, wholesale electricity prices in California were nearly 500% higher than they were during the same months in 1998 or 1999. This price explosion was unexpected and has called into question whether electricity restructuring will bring the benefits of competition promised to consumers. The purpose of this paper is to examine the factors that explain this increase in wholesale electricity prices. We simulate competitive benchmarks for the Summer of 2000 taking account of all relevant supply and demand factors – gas prices, demand, imports from other states, and emission permit prices. We then compare the simulated competitive benchmark prices with the actual prices observed. We find that there is a large gap between our benchmark competitive prices and observed prices, suggesting that the prices observed during Summer 2000 reflect, in part, the exercise of market power by suppliers. We then proceed to examine supplier behavior during high-price hours. We find evidence that suppliers withheld supply from the market that would have been profitable for price-taking firms to sell at the market price.

- [Mansur Erin T. "Vertical Integration in Restructured Electricity Markets: Measuring Market Efficiency and Firm Conduct." CSEM Working Paper 117 \(October 2003\).](#)

While studies have found substantial inefficiencies in some restructured electricity markets, this paper demonstrates two reasons why performance is relatively competitive in the Pennsylvania, New Jersey, and Maryland market. First, in this market, the vertical integration of firms reduces electricity producers' interest in setting high prices: producers sell into the wholesale market and also are required to buy in the market in order to provide power to their retail customers at set rates. Second, I account for production constraints that result in cost nonconvexities. When ignoring these constraints, measures of price-cost margins—which are based on a method common to the literature—imply that market imperfections during the summer following restructuring increased procurement costs 51% (\$950 million). This method further implies considerable welfare loss as actual production costs exceeded the competitive model's estimates by 12.5%. This paper develops a consistent estimate of competitive production decisions and predicts that costs were only 3.4% above competitive levels. Using this method of estimating production, I compare behavior of two producers that have relatively few retail customers with other firms. Consistent with these vertically integrated firms' incentives, only firms with large net selling positions in the market reduced output relative to competitive production estimates.

- [Moss, Diana. "Electricity and Market Power: Current Issues for Restructuring Markets \(A Survey\)." AAI Working Paper 05-01, American Antitrust Institute \(February 2005\).](#)

This paper surveys the legal economic literature on market power in electricity over the last 15 years. Many of the market power issues in electricity fit within the broader, long-familiar rubric of antitrust analysis. But electricity also displays special characteristics and complexities that may require a more tailored approach—or even special guidelines—for competition analysis. Most of the current research regarding market power in electricity focuses on five major areas: (1) withholding; (2) measuring market power; (3) market definition; (4) vertical issues; and (5) remedies. Numerous forms of withholding pose novel and serious policy issues, which are confounded by a

virtually nonexistent role for antitrust and various impediments to effective regulatory enforcement. Much research has also been devoted to measuring market power, particularly in the aftermath of the California energy crisis. While empirical studies that diagnose and quantify market power are useful, they may also deflect attention from the broader issue of structural reforms that would address market power better than behavioral fixes. Market definition has been a key issue in merger and market-based rate policy—revealing the importance of transmission constraints and demand conditions in defining relevant markets. Current modeling approaches are limited in their usefulness, however, thus introducing the debate about the usefulness of simulation models. New vertical issues have also emerged over the last 15 years. New forms of ability to foreclose rivals (e.g., transmission rights and reliability) and incentive (e.g., increased concentration and M&A activity) pose policy challenges in light of renewed interest in the benefits of vertical rebundling. Finally, the research on remedies exposes the tension between structural and behavioral that has polarized antitrust and regulatory approaches to dealing with market power. But outside the realm of merger review, antitrust will likely continue to play a very limited role in electricity, leaving the burden largely on the shoulders of regulators.

- ▢ [Potomac Economics. "2005 State of the Market Report for the ERCOT Wholesale Electricity Markets" \(2006\).](#)

COLLUSION

- ▢ [Le Coq, Chloé. "Index Contracts and Spot Market Competition." CSEM Working Paper 153 \(June 2006\).](#)

It has long been argued that long-term contracts enhance competition, but the repeated nature of many markets has been neglected. This paper analyzes the impact of long-term contracts on the ability to sustain collusive outcomes. I consider a simple model where firms have signed index contracts and repeatedly interact on the spot market. The contracts specify a quantity and a price indexed to the spot price where the indexation can take different forms. It is shown that these contracts facilitate collusion on the spot market provided that the indexation to the spot price is sufficiently strong.

- ▢ [Hogendorn, Christiaan. "Collusive Long-Run Investments Under Transmission Price-Caps." *Journal of Regulatory Economics* 24, 3 \(November 2003\): 271-291.](#)

In the short run, constraints in the electricity transmission system may give market power to generators. This paper examines whether the constraints themselves are a long-run equilibrium outcome in a competitive environment. We show that independent transmission companies and generators can tacitly collude to raise prices to consumers and divide the resulting profits. We also show that price cap regulation does not prevent this behavior and may in fact contribute to it. The mechanism for collusion is that generators locate their plants so that a capacity-constrained transmission line lies between them and their consumer market. We show that this constraint-based collusion can be sustained in a static game without any punishment strategies.

- ▢ [Kahn, Alfred E., Peter C. Cramton, Robert H. Porter, and Richard D. Tabors. "Pricing in the California Power Exchange Electricity Market: Should California Switch from Uniform Pricing to Pay-as-Bid Pricing? Blue Ribbon Panel Report." A study commissioned by the California Power Exchange \(January 23, 2001\).](#)

- ▢ [Kühn, Kai-Uwe. "How Market Fragmentation Can Facilitate Collusion" \(October 2006\).](#)

When regulated markets are liberalized, economists always stress the benefits of fragmenting existing capacities among more firms. This is because oligopoly models typically imply that a larger number of firms generates stronger competition. I show in this paper that this intuition may fail under collusion. When individual firms are capacity constrained relative to total demand, the fragmentation of capacity facilitates collusion and increases the highest sustainable collusive price. This result can explain the finding in Sweeting (2005) that dramatic fragmentation of generation capacity in the English electricity industry led to increasing price cost margins.

- Lye, Kong-Wei. "Learning Agents in Power Markets." Ph.D. Dissertation, Dept. of Electrical and Computer Engineering, Carnegie Mellon University (2004).
- [Macatangay, Rafael Emmanuel A.](#) "Tacit Collusion in the Frequently Repeated Multi-Unit Uniform Price Auction for Wholesale Electricity in England and Wales." *European Journal of Law and Economics* 13, 3 (May 2002): 257-273.

Tacit collusion between National Power and PowerGen, the dominant generators in England and Wales for most of the 1990s, was widely speculated but was not definitively proven. In the event of a legal determination, the best available evidence is a test of suspicious patterns of bidding behavior. The methodology has two stages: the first is to show that the suspects behave "differently" from the rest, which are assumed competitive; the second stage is to ask whether or not strategies of suspects affect one another. Results: the impact of suspects on the aggregate bid function can not be explained away by costs and common market events, and a seemingly unrelated regression (SUR) on strategies of the suspects reveals bid inter-dependence and co-ordination on demand trends. A quarter of the dynamic indicators support an inference of tacit collusion. The existence of multiple equilibria in supergames, however, prevents a conclusive statement.

- [Rassenti, Stephen, Vernon Smith, and Bart Wilson.](#) "Controlling Market Power and Price Spikes in Electricity Networks: Demand-Side Bidding." *Proceedings of the National Academy of Sciences* 100, 5 (2003): 2998–3003.

In this article we report an experiment that examines how demand-side bidding can discipline generators in a market for electric power. First we develop a treatment without demand-side bidding; two large firms are allocated baseload and intermediate cost generators such that either firm might unilaterally withhold the capacity of its intermediate cost generators from the market to benefit from the supracompetitive prices that would result from only selling its baseload units. In a converse treatment, ownership of some of the intermediate cost generators is transferred from each of these firms to two other firms such that no one firm could unilaterally restrict output to spawn supracompetitive prices. Having established a well controlled data set with price spikes paralleling those observed in the naturally occurring economy, we also extend the design to include demand-side bidding. We find that demand-side bidding completely neutralizes the exercise of market power and eliminates price spikes even in the presence of structural market power.

- [Rothkopf, Michael H..](#) "Control of Market Power in Electricity Auctions." RRR 8-2001 (January 2001).

In a number of jurisdictions, deregulation has led to the establishment of auction spot markets for electricity supply. Short run demand for electricity is almost totally inelastic, and in most situations economically significant amounts of electricity cannot be stored. During periods when demand is relatively high, suppliers with what, in other markets, would be regarded as a relatively small percentage of the industry total capacity have and have exercised extreme market power. This paper proposes and discusses a narrowly targeted and automatic remedy that will keep suppliers with the capacity and incentive for exercising such power from any role in setting the market-clearing price.

- [Schultz, Christian.](#) "Virtual Capacity and Tacit Collusion." *Centre for Industrial Economics Discussion Papers* (2004).

In several European merger cases competition authorities have demanded that the merging firm auctions of virtual capacity. The buyer of virtual capacity receives an option on an amount of output at a pre-specified price, typically equal to marginal cost. This output is sold in the market in competition with the merging firm. The paper compares sale of physical and virtual capacity by the merging firm and shows that virtual capacity makes tacit collusion easier. The reason is that the auction price on virtual capacity increases, when the merging firm reduces production in order to increase the output price. This reduces its temptation to deviate.