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Abstract

Electric power is one of the last major regulated industries to undergo some form of "liberalization." One of the most important steps has been creating regional transmission organizations (RTOs) in major regions of the country. RTOs are independent non-profit entities that operate utility-owned transmission networks. They are intended to increase competition and efficiency in the market for wholesale power, which should lead to lower wholesale prices. This paper tests whether RTOs have, in fact, achieved this goal.

Our results indicate that RTOs have not lowered wholesale prices. Controlling for fuel costs and shares, and state- and time-specific factors, we find that prices in areas with RTOs have been higher than otherwise would have been the case. Our results also show that this outcome is not a reflection of initial market design flaws that subsequently have been corrected. RTOs that have been in operation longer have not as yet provided benefits in the form of lower wholesale prices.

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I. Introduction

Starting with the airlines in the late 1970s, economists have generally found that deregulation has benefited consumers. Winston (1998), summarizing the evidence, shows that operating costs declined substantially following deregulation for a broad range of industries, including trucking, railroads, banking, and natural gas, as well as airlines. Much of those savings has been passed through to consumers in the form of lower prices.

Electric power is one of the last major regulated industries to undergo some form of "liberalization." Over the past 15 years, the electricity sector has undergone wide-ranging regulatory and structural reforms at both the wholesale and retail levels. Sufficient data now exist to evaluate these reforms.

Both the electricity industry and its legacy regulatory structure are complex. As a consequence, electricity liberalization has been complicated, involving interrelated actions at the retail and wholesale levels. One of the most important steps has been creating regional transmission organizations (RTOs) in major regions of the country. RTOs are independent non-profit entities that operate utility-owned transmission networks. They perform a variety of functions designed to yield more competitive and more efficient wholesale power markets. This, in turn, should lead to lower wholesale prices. The purpose of this paper is to test whether RTOs have, in fact, achieved this goal.

Our results indicate that RTOs have not lowered wholesale power prices. Instead, after controlling for fuel costs and shares, and state- and time-specific factors that might have led to higher prices in RTO states, we find that prices in areas with RTOs have been higher than otherwise would have been the case. These results are consistent across a range of econometric specifications.

II. Competition in Wholesale Electricity Markets

Historically, vertically integrated, regulated utilities undertook all major functions of electricity provision—generation, transmission, distribution, and retailing. The "competitive" model toward which the industry has been moving reflects the view that generation (wholesale power) and retailing (energy services) can be competitive, but the "wires"—transmission and distribution—retain natural monopoly characteristics and therefore need to remain subject to regulation. The major challenge at the wholesale level has been how to structure the transmission network to facilitate competition in the market for wholesale power.

Generators and marketers wishing to compete in the wholesale power market need access to transmission. Moreover, integrated utilities—i.e., transmission owners who also own generation facilities—should not be able to discriminate in anticompetitive ways in favor of their own generation. Starting in the early 1990s, Congress and the Federal Energy Regulatory Commission (FERC) adopted a series of measures to accomplish these goals. The Energy Policy Act of 1992 gave independent generators and traders the ability to petition FERC to order integrated utilities to provide access to their transmission networks after the utility's native load requirements was met. Subsequently, in 1996, the FERC required transmission utilities to provide non-discriminatory open access to their systems. At the same time, many utilities divested themselves of substantial amounts of generation capacity, voluntarily or because state regulators encouraged them to do so.

FERC and many economists argued these steps were not sufficient. They believed it was also necessary to divide the country into large RTOs which would operate the transmission infrastructure (see FERC, 1999). These RTOs, which have been adopted in the Northeast, Mid-Atlantic, Midwest, Texas, and California, further separate the competitive generation sector from the transmission network. In addition, RTOs play a critical role in designing and operating auction-based wholesale power markets, planning for infrastructure expansion, and monitoring markets for the possible exercise of market power.[1] All of these functions are intended to produce a more competitive and more efficient market for wholesale power, which should lead to lower wholesale prices and, presumably, reductions in the retail prices for electricity paid by residential, commercial, and industrial users.

The implementation of RTOs has varied widely across regions of the country. California, one of the earliest RTOs, mandated large-scale divestiture of power generation facilities by the incumbent investor-owned utilities and sharply limited long-term contractual commitments between generators and retailers. In contrast, the Electricity Reliability Council of Texas (ERCOT) operates a system that uses centralized dispatch only to clear imbalances in the existing schedule of bilateral transactions, and retailers still retain ownership of many of the power generating facilities.[2]

Both the "market design" and management of existing RTOs continue to evolve. This evolution has made it difficult to determine the extent, if any, to which the operation of wholesale markets by RTOs has produced savings in electricity costs. The analysis is further

[1] The FERC (2004) report on RTO costs distinguishes between "Day One" RTOs, which perform grid management and market monitoring functions but do not operate bid-based wholesale markets and "Day Two" RTOs, which also operate organized wholesale markets. The model specifications tested in this paper focus specifically on the impact of these Day Two RTOs.

[2] While ERCOT is not technically a RTO (because FERC does not have jurisdiction over the single-state transmission network that serves most of Texas), it performs many of the same functions as RTOs and has operated an organized wholesale electricity market since 2001.

complicated by changes in the retail electricity market, which have increased the range of electricity choices available to consumers, particularly large industrial and commercial users. Moreover, this restructuring has taken place against the backdrop of rising energy prices in recent years, resulting in higher electricity costs in RTO and non-RTO regions alike.

In principle, RTOs promise to reduce wholesale electricity costs by increasing competition and efficiency in the wholesale power and transmission sectors. In practice, however, RTOs may not have had those positive effects. It is possible that the pre-RTO measures adopted to promote wholesale competition—most prominently, the open access requirements—were effective and that the marginal benefits of proceeding further with the implementation of RTOs were small or nonexistent. It is also possible that RTOs have not only failed to produce benefits, but have actually been counterproductive and made wholesale electricity markets less competitive.

III. Previous Studies

Studies of the effect of restructuring the electric power industry typically focus on either retail or wholesale market restructuring. Some studies use price (usually at the retail level) as the measure of the impact of restructuring; some studies focus on production costs. Other studies try to assess the costs and benefits of various restructuring regimes.

A recent review paper by Kwoka (2006) highlights the results and limitations of 12 studies conducted between mid-2003 and mid-2006. Kwoka takes issue with each of these studies to varying degrees for limitations in the economic modeling, data, and interpretation of results. Two studies (Joskow, 2006; and Taber *et al.*, 2006) come closest to meeting the criteria that Kwoka enumerates for valid research, but reach opposite conclusions about the benefits to consumers and other power users from the restructuring of the electric power market. Joskow finds that both retail and wholesale competition have led to lower retail prices. In contrast, Taber *et al.* find that wholesale competition—measured by whether or not a state belonged to an Independent System Operator (ISO) with an auction-based market—has not resulted in lower retail prices.[3]

Other researchers have focused on measuring the cost savings in power generation and operating expenses. Several studies find efficiency gains from the changes in ownership and operation of power plants that have taken place in restructured markets. Fabrizio *et al.* (2007) find that investor-owned generation plants in restructured states reduced labor and other nonfuel operating costs by 3 to 5 percent, relative to states that did not restructure. Barmack *et al.* (2006) find that restructuring the wholesale market in New England reduced costs by about 2 percent, principally as a result of more efficient operation of nuclear plants. Similarly, Tierney and Kahn (2007) find net benefits from the New York ISO, also as a result of improved performance of nuclear plants. However, none of these studies investigates whether these cost savings are reflected in lower average wholesale or retail electricity prices.

Mansur and White (2008) evaluate the merits of RTO-organized auction markets compared to the decentralized bilateral trading that characterizes non-RTO markets. (RTO markets are sometimes referred to as "organized" markets.) They find that PJM (the mid-Atlantic RTO) realized substantial efficiency benefits in 2004 when it expanded and incorporated a large new area into its organized auction-market regime. This study also does not address whether these efficiencies are reflected in lower average wholesale or retail prices.

[3] ISOs are non-profit entities that manage utility-owned transmission assets and are responsible for scheduling and dispatching power. Thus far, in areas where an ISO exists, the incumbent ISO has become the FERC-approved RTO. The terms are frequently used interchangeably.

Harvey *et al.* (2007) come closest to addressing the question we address of the effect of RTOs on wholesale prices. They compare retail-level electricity prices for munis and coops, adjusted for a number of factors, in states within the PJM and New York RTOs with those in an adjacent region (the Southeast) where similar restructuring has not occurred. They find that PJM and the New York RTO have led to wholesale power cost savings between 2000 and 2004.

The Harvey *et al.* study, however, has two shortcomings that call into question its conclusion. First, the econometric analysis uses retail prices. Even though the prices are for munis and coops, which the authors argue more accurately reflect changes at the wholesale level, these retail prices are still influenced by a number of market and regulatory factors that are irrelevant to—but likely to confound—analysis of the wholesale power market. Second, the principal results hang by a thin thread: the predicted power prices in nearly all of the RTO states included in the study (all but Pennsylvania and western Maryland in the basic specification) are modeled solely on the relationship between pre-restructuring prices in these states and those in Florida, the only state in the non-RTO region covered by the study that has a comparable share of electricity generated by natural gas.

IV. Estimating the Effect of RTOs on Wholesale Power Prices

Wholesale Power Price and Fuel Cost Data

Most analysts have thus far used retail-level electricity prices in their assessments of the effects of electricity restructuring, but these data are less than ideal for evaluating the impact of RTOs. Retail prices include distribution, transmission, and other costs that are not relevant to the wholesale market. In addition, retail prices in states that participate in RTOs have frequently been capped as a condition of moving to retail deregulation.

It is therefore preferable to evaluate the impact of RTOs on wholesale electricity prices directly. Utilities' annual EIA-861 filings (the source for retail price data used by Harvey *et al.* and several of the other studies) report the amount of electricity sold in wholesale power transactions among utilities, other generators, and power marketers, as well as the revenues derived from these sales. From these data, it is possible to derive wholesale power prices for almost every state for the entire period from 1991 through 2006.[4]

These electricity resale data show that the wholesale power market is well-developed, even in regions that do not have RTOs. One concern is that wholesale power transactions in traditional electricity markets may not reflect the complete range of wholesale costs because vertically-integrated utilities generate most of their electricity internally. However, the ratio of wholesale electricity volumes to retail delivery volumes in traditional markets ranged from 74 percent to more than 100 percent (because of multiple resales) during the most recent eight years in our study, suggesting that the market is large enough to provide a meaningful benchmark against which wholesale power prices in RTO states can be evaluated.

Data on fossil fuel costs and the mix of fuel sources to generate electricity are available from two other databases. FERC-423 forms report the costs of individual coal, gas, and fuel oil acquisitions by power generating facilities. We use these individual contract data to derive state-specific measures of average fuel costs for each of the past 17 years. In most years there were no FERC-423 reports for a handful of states, and transactions from a few states are never reported in

[4] Our study excludes only Alaska, Hawaii, and Tennessee, three states for which there are significant gaps in the wholesale power data, and Rhode Island, which had a very small wholesale market (<1,000 MWH annually in the past eight years, with the exception of 2001) during the period studied. By contrast, Harvey *et al.* cover only 13 states and the District of Columbia.

the database. Accordingly, it was necessary to impute one or more of the three component fossil fuel cost variables (coal, gas, and oil costs) for over 100 of the 799 observations in our 47-state, 17-year sample.[5]

The shares of electricity generated from each fuel source, including non-fossil-fuel sources, are available on a state-level basis from EIA, which computes these share estimates from utility data provided on the EIA-906 forms. These data are complete and do not require any imputation.

Model Specification

These wholesale electricity sales and fuel cost/share data can be used to estimate econometric models that meet the criteria set forth by Kwoka for a well-specified analysis of electric power prices:

1. They allow for state- and year-specific fixed effects on electricity prices;
2. They include additional variables that control for variations in fuel sources and changes in fuel prices by state; and
3. They cover a time period that makes it possible to estimate a model that includes both pre-RTO and post-RTO experience.

Following Joskow and others, we estimated average state wholesale electricity prices using panel data models of the form:

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[5] Imputations were required for 97 coal cost, 106 natural gas cost, and 85 fuel oil cost measures in the 799 state-year observations in our sample. The missing values were projected using separate first-order regression equations for each of these three fuel cost measures that included all of the other explanatory variables included in each of the models presented in Tables 1 and 2. This procedure eliminates any covariance between the predicted values and the other independent variables in the equation.

(1) $P_{it} = f(RTO_{it}, FUELCOST_{it}, FUELSHARE_{it}) + \gamma_i + \alpha_t + \varepsilon_{it}$

where *i* indexes states and *t* indexes years; P_{it} is the average wholesale electricity price; RTO_{it} indicates whether a state's utilities are (or how long they have been for some specifications) in an RTO; $FUELCOST_{it}$ is a vector of fossil fuel costs; and $FUELSHARE_{it}$ is a vector of variables representing generation shares from the major fuel sources. The last three terms represent state-specific, time-specific, and random error terms, respectively. We ran several variants of this general model, as explained below.

For this analysis, we defined an RTO as any regional transmission organization or independent system operator (ISO) that the ISO/RTO Council (IRC) reported as conducting wholesale market operations (IRC, 2005 and 2007). We defined a state as an RTO state if all or nearly all of the state was included in an RTO that conducted wholesale market operations.[6] Table 1 shows the states that are included in the various RTOs and when organized wholesale market operations began.

We tested all of the specifications presented in this paper using two alternative measures of fossil fuel costs and fuel shares:

1. The first version of each model includes three variables that represent the state-level average cost of each fossil fuel, *CoalCost, NGasCost, and FuelOilCost*, together with variables for

[6] The status of each state's RTO membership was determined by consulting a set of reference maps provided in the IRC State of the Markets reports. States were considered to be part of an RTO if all of the major metropolitan areas were included in the coverage region (e.g., Dallas, Fort Worth, Houston, and San Antonio are all in the ERCOT area, although some parts of northern and western Texas are not). We also tested an alternative measure of RTO membership that counts states with only partial RTO coverage as being RTO members, an approach that affects certain state-years for Illinois, Missouri, Ohio, South Dakota, and West Virginia. The results from these alternative equations are similar to those reported in the paper.

the shares of electricity generated from nuclear and hydroelectric sources for which meaningful cost data are not available:

$$(2)\qquad P_{it} = C + B_1\, RTO_{it} + B_2 CoalCost_{it} + B_3 NGasCost_{it} + B_4 FuelOilCost_{it} + B_5 NuclearShare_{it} + B_6 HydroShare_{it} + State_i + Year_t + \varepsilon_{it}$$

2. The second version of each model eliminates the three fossil fuel cost variables and models wholesale prices as a function of the generation shares from each of the five fuel sources:

$$(3)\qquad P_{it} = C + B_1\, RTO_{it} + B_2 NGasShare_{it} + B_3 FuelOilShare_{it} + B_4 NuclearShare_{it} + B_5 HydroShare_{it} + State_i + Year_t + \varepsilon_{it}$$

Each of these approaches has advantages and drawbacks. Using fuel cost variables generates results more directly comparable to those in Joskow and in Harvey *et al.*, but, as discussed, requires imputations to account for missing data in as many as one-third of the states for any given year. The fuel-share-only approach eliminates the need to impute missing values, but prevents us from using fluctuations in fuel costs to help explain state electricity prices. However, as our discussion of the results below indicates, these two alternative approaches yield very similar results for the RTO-related variables in nearly all of the specifications presented in this paper.

Estimation Procedures

Causation is an issue in virtually every empirical study of the effects of electricity restructuring. In our case, the concern is that states with higher wholesale prices may have been more likely to participate in RTOs. This was the case for the four RTOs (California ISO, ISO

New England, New York ISO, and PJM Interconnection) that began wholesale market operations in 1998 and 1999.[7]

Participation in an RTO is, however, only partly a state decision. Wholesale power markets and interstate transmission—and, therefore, RTOs—come under the jurisdiction of the federal regulator, FERC.[8] This makes it somewhat more likely that establishing an RTO was exogenous.

Nevertheless, we control for potential endogeneity bias by using OLS and GLS panel data estimation methods that take into account fixed state- and time-specific effects (one of Kwoka's criteria for a well-specified model). This approach ensures that the variable used to identify participation in an RTO does not reflect state differences in pre-RTO price levels.

Applying OLS and GLS methods to panel data generally yields similar results when there are a relatively small number of observations in each time period, as is the case when a model with state-level data is run over a significant span of time (Wooldridge, 2002). In this case, however, the degree of year-to-year variation in average electricity prices differs substantially among states over the time period studied. For some states, average wholesale prices fluctuated to levels several times those seen in the previous year, not only during the California crisis of 2000 and 2001, but also during the two most recent years (2005 and 2006) for which we have data. In other states, price changes have been consistently modest and gradual. Moreover, even when state- and year-specific factors have been controlled for, there are residual serial correlations in the error terms across states for the predicted price values over time.

[7] Joskow (2005, p. 35) cites legacy costs of nuclear plants and above-market contracts to PURPA qualifying facilities as major reasons why real retail electricity prices in California and the Northeast did not follow the national downward trend in the late 1980s and early-mid 1990s.

[8] The exception is ERCOT, which is not under FERC jurisdiction, because Texas is a self-contained market.

Accordingly, we present results in Tables 2 through 4 below from models that incorporate successively more detailed controls for these potentially confounding factors. The following four specifications are presented:

1. OLS estimates with state-specific fixed effects.
2. GLS estimates adjusted for heteroskedastic variances of the error terms, but without controlling for residual state-specific effects;
3. Heteroskedasticity-corrected GLS estimates with state-specific fixed effects; and
4. Heteroskedasticity-corrected GLS estimates with state-specific fixed effects and first-order correction of serial correlation in the error terms within panels.[9]

Results

We initially estimate all four models using a single RTO dummy variable set equal to 1 for state-year observations in which an RTO was operating. Table 2 provides a side-by-side comparison of the results from the fossil fuel-cost and fuel-shares-only versions of the equation. Table 2 also reports the coefficients estimated for the year dummies (which reflect higher prices during the California electricity crisis of 2000-2001 and a rise in prices during the three most recent years in our sample).

Our results show that RTO membership is consistently related to higher average state wholesale electricity prices. Prices in RTO-member states have been \$2-\$3/MWh (about 4 to 6 percent of the 2006 average wholesale price of \$53/MWh) higher on average than in states without organized wholesale markets. This result is consistent across all four specifications,

[9] The auto-correlation process and correction is assumed common to all of the state panels. State-specific adjustments for serial correlation would be possible only if the number of time points exceeded the number of panels being studied.

each of which controls for pre-RTO differences in average state wholesale prices and variations over states and time in fuel sources and costs.

The estimated positive effect of RTOs on wholesale electricity prices is quantitatively similar in the OLS and GLS models, although the statistical significance of the RTO coefficients is uniformly higher in the GLS equations. Adding state-specific dummies strengthens the statistical significance of the overall GLS equation results and reduces the sensitivity of predicted state prices to changes in fuel costs or the mix of fuel sources used in generation.[10]

In general, including fossil fuel costs does not improve the explanatory power of the model over that obtained using only the fuel share variables in any of the four specifications.[11] One possible reason for the lack of improvement from using fuel costs is that fossil fuels either individually or collectively represent a relatively small share (less than 25 percent in Washington and Oregon and less than 50 percent in New York and most of New England in 2006) of the overall generating cost for some states. In addition, variations in average state wholesale electricity prices may be more sensitive to variations in the costs of the fuels used to meet peak power needs, rather than those used to meet the bulk of baseline demand for electricity.[12] It is also possible that some of the FERC-423 reports from which these fuel cost data are derived may be incomplete or inaccurate.

[10] This diminished sensitivity of the estimated impact of RTO membership to fuel costs and shares once state-specific effects are taken into account more completely is reflected in the closer agreement of the RTO coefficients obtained from the "Costs" and "Shares" variants of the models, as well as the reduced significance of the fuel source variable coefficients.

[11] Because the fuel-cost and fuel-share results are similar across model specifications, we did not compute adjusted standard errors for the fuel cost variable coefficients to account for the impact on precision of imputing the missing fuel cost observations. Accordingly, the statistical significance levels reported on the statistical output for the fuel cost variables somewhat overstates the true precision of these coefficients.

[12] For example, in several states the majority of electricity generated is from coal-fired plants, which have experienced relatively modest increases in fuel costs until recently, but peak-load demands are served primarily by gas- and oil-fired plants with more volatile fuel costs.

Time-Specific Effects of Organized Wholesale Electricity Markets

It is possible that the above results reflect the early experience of organized markets, particularly the one in California, but that the performance of RTOs has improved as structural flaws have been corrected and RTOs have moved toward the standard market design approach promoted by FERC in recent years. We examined this possibility using two alternatives to the single RTO dummy variable equation:

1. An *RTO Years* variable equal to the number of years the state has been in an RTO with wholesale market operations. [13] A negative coefficient would be consistent with the hypothesis that RTOs experience initial difficulties, but improve over time.
2. Two RTO dummy variables: an *RTO Pre-2003* dummy which equals 1 if the state was in an RTO prior to 2003; and an *RTO-Post 2002* variable which equals 1 if the state was in an RTO after 2002. [14] This variant of the model tests the hypothesis that the first RTOs had structural problems that offset their competition-enhancing attributes, but those that have come online more recently largely avoided these problems.

The results from using these alternative RTO variables confirm and strengthen those from our single RTO-membership variable equations. The estimates for the *RTO Years* coefficient

[13] In a few states (Illinois, Missouri, and Ohio), wholesale market operations began in part of the state under one RTO, but a second RTO with coverage in the remainder of the state did not begin wholesale market operations until a later year. For these states, the count of *RTO Years* begins with the first year that all (or substantially all) of the state was included in one or more RTOs. Similarly, the split dummy variable approach does not count these "partial-RTO" states as participating in an organized wholesale electricity market until coverage of the state was substantially complete.

[14] Splitting the RTO variable into two separate dummies between 2002 and 2003 yields an approximately equal number of observations with values of "1" for the two variables. However, the results are not sensitive to the choice of years included in the "post" and "pre" periods.

indicate that each year of RTO membership adds from $0.67 to $1.13 to the cost of each MWh of electricity sold in an organized wholesale market. In other words, the positive (i.e., adverse) effect on wholesale electricity prices increases with years of participation—perhaps because participating electricity resellers become increasingly adept at exploiting the hourly auction system, a possibility we discuss in more detail below. These results suggest that the benefits of RTOs have not materialized even in the wholesale markets that have been in operation for the longest period of time.[15]

Similarly, the estimated coefficients on the "split" dummy variables in the second set of models presented in Table 3 indicate that the adverse impact of RTO membership on wholesale electricity prices has become substantially more pronounced in the most recent four years in our sample. These results suggest that the actions taken to correct pre-2003 defects in structure and bidding procedures of the organized wholesale markets operating in California, Texas, and the northeastern and mid-Atlantic states—such as the June 19, 2001 FERC price-mitigation order that Wolak (2005) cites as improving market performance in California—have failed to mitigate the adverse impact of RTOs on wholesale electricity prices.[16] In fact, states participating in RTOs experienced higher-than-average rises in average prices during the most recent two years (2005 and 2006) in our sample, when fossil fuel costs rose substantially in both RTO and non-RTO states.

[15] Of course, it may turn out that the relationship between years of RTO participation and wholesale electricity prices can be better modeled using a non-linear specification as more of the RTO-organized markets have operated for an extended period of time.

[16] The GLS specification that includes state dummy variables but no autocorrelation correction does not fit this overall pattern. However, the "fuel cost" version of this equation does show the pattern of increasing adverse impact in more recent years evident in the other three specifications. This is the only case in which the fuel "cost" and "share" variants of the equations shown in Table 3 do not yield similar estimates of the impact of RTO membership in the pre-2003 and post-2002 periods.

RTO-Specific Estimates

Another possibility is that some RTOs have done poorly at generating benefits from competition, while others have performed well. This hypothesis can be tested by replacing the single RTO membership dummy variable with separate dummy variables for each individual RTO which had begun wholesale market operations by 2006.

Table 4 presents the estimated coefficients for the individual RTO variables when they are substituted for the single-RTO dummy in each of the eight equations first presented in Table 2. The results from the individual RTO equations generally confirm the results from the single-RTO models. With the exception of ISO New England, RTOs have failed to deliver lower wholesale electricity prices. The coefficients for California, ERCOT and PJM are all positive and significant at the 90-percent level or better in all of the GLS specifications.

The magnitudes of the estimated RTO-specific effects on prices are substantial. While it is not surprising that the coefficients on the California ISO variable are the largest in all three models, we estimate that the membership in the ERCOT (Texas), Midwest ISO, or PJM Interconnection RTO imposes a burden ranging between $1.55 and $11.41 per MWh in higher wholesale electricity prices.

The results indicate that the New England ISO has resulted in lower prices. A possible explanation for this is discussed in Section V, below.

Comparability with Harvey et al. (2007) Results

Finally, we re-ran the two GLS models with state dummies (the equations with and without the autocorrelation adjustment) utilizing only the states included in the Harvey *et al.* (2007) comparison of wholesale prices in the PJM/NYISO states with those in the six southeastern states that do not belong to an organized market. Unlike the Harvey *et al.* model, we did not "match" states on the basis of predominant fuel source, so Florida alone does not serve as the benchmark for New York and all of the PJM states in which natural gas is the primary fossil fuel.

The results in Table 5 show that even if the analysis is performed using only the restricted sample of states in Harvey *et al.* (2007), membership in an organized market has an adverse, statistically significant impact on average state wholesale electricity prices. The magnitude of this adverse effect is actually substantially larger than estimated for the entire U.S. sample, whether measured using a single dummy variable (Table 2), a "RTO Years" or "split" dummy variable (Table 3), or separate dummy variables for NYISO and PJM (Table 4).

V. Discussion of Results

RTOs were expected to produce more competitive, efficient markets. If those expectations were realized, the result should be lower wholesale prices. Thus far, according to our results, this has not happened. In the single-RTO-variable models, the RTO coefficient is positive and highly significant. These models indicate that wholesale prices in the RTO states are on average about 4 percent higher than they would be without RTOs.

One possible concern is that the single-RTO-variable model results are overly influenced by the experience of California. When we separate out the effects of the individual RTOs, the California ISO coefficient is large and highly significant.[17] However, the coefficients on the ERCOT and PJM dummy variables are also positive and significant, albeit smaller than those for California. Thus, generator cost reductions such as those estimated by Fabrizio *et al.* (2007), as well as the market efficiencies identified by Mansur and White (2008), have not been reflected in wholesale prices in most areas with organized (RTO) wholesale electricity markets, according to our results.

Our results show ISO New England to be the only RTO that has lowered wholesale prices. This may be explained by the more efficient operation of nuclear plants in the region found by Barmack *et al.* (2006). However, similar efficiencies observed for the New York ISO (Tierney and Kahn, 2007) do not appear to have been sufficient to lower wholesale prices there.

Overall, our results are consistent with those from some previous studies that also failed to find measurable benefits from organized electricity markets. As discussed above, Taber *et al.* (2006) found that retail prices were not lower in "deregulated" states—defined as states in which the utilities were members of ISOs—as compared to "regulated" states. Our results have the advantage that they are based on wholesale rather than retail prices as the dependent variable. In principle, wholesale prices should provide a more direct measure of the effect of RTOs, since RTOs (and ISOs) are a critical component of wholesale deregulation, while many other factors influence retail prices. On the other hand, there may be a potential selection bias if the external

[17] A similar pattern of results, but with smaller magnitudes on many of the positive RTO coefficients, is obtained for the model specifications shown in Tables 2, 3 and 4 when all of the California observations are dropped from the estimation.

generation costs of vertically-integrated utilities, which are more prevalent in non-RTO states, are lower than their internal costs.[18]

Our study also has three additional years of data, which is critical for studying the effects of RTOs since many of them have only been operating organized markets for a short time. Finally, our study does not suffer from the deficiencies identified by Kwoka (2006).

The potential for large generators to exercise market power in organized markets is often cited as a possible explanation for the lack of benefits from electricity market restructuring. Among others, Wolak (2003) has devoted considerable attention to the 2000-2001 California market disruptions, and has shown that the California ISO market design abetted the exercise of market power by a few large generators. While many observers of the California market concluded that the 2000-2001 electricity price shocks must have resulted from collusive behavior, Wolak demonstrated that the market was tight enough for the largest generators to exercise market power unilaterally.

Market power alone is not sufficient to explain our results, however, since our estimates suggest that organized markets not only have failed to restrain wholesale electricity prices, but may actually have contributed to their increase. This result is consistent with the analysis of Blumsack *et al.* (2005), who argue that the hourly-auction market structure adopted by organized markets has facilitated tacit collusion by generators bidding into the auction and therefore increased their ability to exercise market power. Even with a relatively large number of generators, a small group of bidders may frequently be able to withhold supply and raise prices. The ability of generators to act strategically is enhanced by the RTO practice of announcing demand forecasts in advance. Moreover, generators who interact frequently with each other are

[18] However, the relatively large volume of wholesale electricity sales relative to retail deliveries in non-RTO states should limit the quantitative significance of this potential selection bias.

well-positioned to learn each others' strategies, further facilitating tacit collusion. Blumstack *et al*. also suggest that the failure of RTOs to operate markets for some ancillary services—in particular, reactive power—has contributed to market power problems.

Congestion problems in some organized markets may also contribute to the ability of generators to act strategically and raise prices.[19] Congestion indicates that transmission prices are not equilibrating local transmission markets and that the transmission owners are therefore not receiving all the congestion rents. Using an experimental approach, Backerman *et al.* (2000) show that, in this situation, generators at the end of the constrained lines are able to increase their profit share and capture most of the congestion rents that should be going to transmission owners.

Blumsack *et al*. (2005) show that price-responsive demand could alleviate these problems, a result earlier found by Rassenti *et al.* (2003) in an experimental setting. In the absence of elastic demand, however, the result is high prices. These are kept in check somewhat by RTO market monitors, but this activity is arguably just another form of rate regulation.

Vertical disintegration may help explain the relative increase in prices in organized markets. Bushnell *et al.* (2007) show that vertically integrated wholesalers in electricity markets, or equivalently, wholesalers with long-term contracts, have less incentive to raise wholesale prices when retail prices are determined beforehand. In the traditional markets, utilities are vertically integrated—presumably more so than in the organized markets where there is more separation between the wholesale and retail markets. This effect of vertical integration is consistent with our results that wholesale prices are lower in the traditional markets. It also raises questions about the pro-competitive effects of vertical disintegration.

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[19] See North American Electric Reliability Corporation (NERC) data on Transmission Loading Relief (TLRs) at http://www.nerc.com/docs/oc/scs/logs/trends.htm

Finally, FERC market power rules may be part of the explanation. Generators need FERC permission to charge market-based rates instead of being subject to cost-based rate regulation. RTO membership appears to have made it easier to obtain that permission.[20] If generators in RTO states are less likely to be subject to regulation, they are more likely to charge rates that reflect marginal costs, which, in electricity markets, may be much larger during peak-load periods than the average-cost prices under regulation. In this case, these higher prices would presumably be more efficient.

It is important to keep in mind, however, that while economists hoped that electricity restructuring would rationalize pricing, there was also a widespread belief that regulation had kept prices at supra-competitive levels. The rationale for introducing competition in generation was to lower costs and prices.

VI. Entry as an Extrinsic Test of Competitive Benefits

The 2000-2001 California crisis affected the entire nation—not only in the form of sharply higher average state electricity prices (including many states east of the Rocky Mountains), but also by inducing a large increase in the numbers of utilities, merchant generators, and power marketers participating in the wholesale electricity market. One indication of whether participation in RTO markets was pro-competitive in 2001 is whether the increase in the number of wholesale electricity resellers in RTO states was proportionately larger than in non-RTO states. Another indication is whether the new re-sellers who entered the market in 2001 had any continuing presence or influence in successive years.

[20] The FERC market-based pricing order (FERC, 2007) states: "The first step for a seller seeking market-based rate authority is to file an application to show that it and its affiliates do not have, or have adequately mitigated, market power. Sellers can refer to RTO/ISO monitoring and mitigating as a factor."

As Table 6 shows, the California crisis spurred a dramatic expansion in the number of electricity wholesalers on a nationwide basis in 2001. The percentage increase in participation was larger in states with established organized wholesale electricity markets, even excluding California from the analysis. However, as average electricity prices decreased in 2002, the number of wholesale electricity sellers contracted to below pre-2001 levels in both the organized and traditional markets, with a larger percentage decrease in areas with RTOs. Among the largest states that have been members of RTOs with organized wholesale markets during the past eight years, only California had more wholesalers participating in the market in 2006 than in 1999.

Thus, the data reported to the Energy Information Administration suggest that states with organized wholesale electricity markets have not seen any lasting increase in the number of participants, relative to either the pre-RTO period or states that have not adopted RTOs.

VII. Conclusion

Developing and implementing new wholesale electricity markets has required great expenditures of institutional effort and resources, and has left a continuing burden in the form of surcharges on electricity prices and providers to cover the costs of RTOs. It is fair to expect that this commitment should provide a reasonable return in the form of lower prices in organized wholesale electricity markets. Our results suggest that thus far, this expectation has not been met. In most areas, the emergence of RTOs that conduct wholesale market operations has resulted in higher prices paid to resellers of electricity. RTOs have not improved on the measures that had already been adopted to promote wholesale competition.

Moreover, our results are not a symptom of poor initial market design in areas such as California, but rather a more general indictment of the performance of RTOs. Our results demonstrate that RTOs that have been operating longer still have not yielded lower wholesale electricity prices. There appears to be much work still to do before the promise of competition is realized in areas that currently have organized wholesale markets. Regulators in regions still served by traditional markets would do well to wait for the results of these efforts to be evaluated before moving to develop and implement new RTOs.

Table 1
State Participation in RTOs

RTO	Acronym	States Included	Wholesale Market Operations Began:
California ISO	CAISO	California	1998
Electricity Reliability Council of Texas	ERCOT	Texas	2001
ISO New England	ISONE	CT, MA, ME, NH, RI, VT*	1999
Midwest ISO	MISO	IA, IL (part), IN, MI, MN, ND, OH (part), WI**	2005
New York ISO	NYISO	New York	1999
PJM Interconnection	PJM	DC, DE, IL (part), MD, PA, NJ, OH (part), VA, WV (part before 2005)***	1998
Southwest Power Pool	SPP	AR (part), KS, LA (part), NM (part), OK	2007

*RI was excluded because of very low volume of reported wholesale market transactions.

**The MISO and PJM dummies for IL, OH were coded as "0" because significant portions are in both RTO areas.

***The PJM dummy variable for VA and WV was coded as "1" only in 2005 and 2006.

Table 2: Impact of RTO Membership on Wholesale Electricity Prices ($/MWh)

	OLS fixed-effects		GLS		GLS w/ state fixed-effects		GLS w/ fixed-effects & autocorrelation correction	
	Costs	**Shares**	**Costs**	**Shares**	**Costs**	**Shares**	**Costs**	**Shares**
RTOMember	2.03	1.99	3.39 **	2.29 **	3.14 **	3.41 **	2.69 **	2.91 **
CoalCost	-2.34		8.81 **		0.31		-0.08	
NGasCost	0.20		-0.19		0.08		0.09	
FuelOilCost	-1.24 **		-0.73 **		-0.47 *		-0.26	
NGasShare		2.03		21.13 **		10.67		6.25
FuelOilShare		29.45 *		18.10 **		18.86		12.73
NuclearShare	-10.61	2.22	-1.45	14.93 **	-2.17	5.75	-9.22	-5.42
HydroShare	-15.44	-12.88	-2.73 **	1.32	-3.52	-2.05	-14.20	-13.47
_1991	-2.32	-1.96	-2.15	-2.23 *	-1.98 *	-1.87 *	-1.81 *	-1.74 *
_1992	-3.15	-2.28	-2.28 *	-2.19 *	-2.24 **	-1.96 *	-2.09 *	-1.90 *
_1993	-3.84 **	-2.70	-2.35 *	-2.64 **	-2.81 **	-2.44 **	-2.62 **	-2.40 **
_1994	-4.20 **	-2.79	-1.49	-2.24 *	-2.01 *	-1.65	-1.84	-1.60
_1995	-3.75 *	-2.25	-2.31 *	-3.80 **	-3.35 **	-3.13 **	-3.09 **	-2.93 **
_1996	-5.94 **	-5.21 **	-3.15 **	-5.17 **	-4.35 **	-4.45 **	-4.36 **	-4.33 **
_1997	-6.43 **	-5.05 **	-3.15 **	-4.96 **	-4.80 **	-4.58 **	-4.84 **	-4.59 **
_1998	-5.79 **	-3.63 *	-2.90 **	-4.00 **	-3.99 **	-3.55 **	-3.96 **	-3.66 **
_1999	-4.63 **	-3.10	-0.86	-1.89	-1.82	-1.66	-2.08 *	-1.89 *
_2000	5.58 **	4.77 **	5.84 **	2.58 *	3.52 **	2.73 **	2.75 **	2.51 **
_2001	15.93 **	15.21 **	12.19 **	9.00 **	9.31 **	8.58 **	8.75 **	8.58 **
_2002	-2.42	-2.38	-0.61	-3.91 **	-2.23 *	-2.97 **	-2.87 **	-3.16 **
_2003	0.72	-0.07	2.78 *	-0.73	0.54	-0.16	-0.39	-0.53
_2004	3.76	1.48	5.62 **	1.20	2.95 **	1.73	1.82	1.42
_2005	16.54 **	9.76 **	13.50 **	6.87 **	10.21 **	7.09 **	8.43 **	6.99 **
_2006	21.37 **	12.01 **	15.65 **	9.30 **	14.01 **	9.80 **	11.57 **	9.50 **
_constant	49.60 **	36.68 **	28.55 **	31.51 **	31.09 **	29.01 **	30.45 **	29.24 **
F-value	17.57	17.71						
Wald chi-square			751	865	1631	1608	1023	1028

Fuel Costs = EIA-423 average costs for coal, gas, and oil (scaled x 100)

Fuel Shares = EIA-906 state % generated from gas, oil, etc.

RTO Member = 1 only if all or nearly all of the state included in RTO that conducted wholesale market operations.

** significant @ 95% confidence level

* significant @ 90% confidence level

Table 3: Impact of RTO Participation over Time ($/MWh)

	OLS fixed-effects		GLS		GLS w/ state fixed-effects		GLS w/ fixed-effects & autocorrelation correction	
	Years	**Split**	**Years**	**Split**	**Years**	**Split**	**Years**	**Split**
RTO Years	0.80 **		0.67 **		1.10 **		1.13 **	
RTO Pre-2003		0.01		0.87		4.86 **		1.12
RTO Post-2002		3.89 **		3.48 **		1.77		4.25 **
NGasShare	3.33	2.85	20.72 **	21.10 **	11.18	11.10	7.26	6.86
FuelOilShare	39.32 **	32.37 **	17.66 **	18.58 **	30.29 **	20.99	23.29 *	13.72
NuclearShare	4.92	3.34	14.09 **	15.03 **	7.40	6.17	-3.94	-5.30
HydroShare	-15.59	-14.72	1.18	1.49	-4.08	-3.79	-15.34 *	-14.68
_1991	-1.98	-1.98	-2.23 *	-2.16 *	-1.90 *	-1.82 *	-1.77 *	-1.70 *
_1992	-2.28	-2.30	-2.23 *	-2.19 *	-2.08 *	-2.01 *	-1.99 *	-1.93 *
_1993	-2.69	-2.71	-2.69 **	-2.58 **	-2.53 **	-2.43 **	-2.49 **	-2.38 **
_1994	-2.75	-2.80	-2.27 *	-2.26 *	-1.72 *	-1.73	-1.65	-1.63
_1995	-2.10	-2.22	-3.85 **	-3.79 **	-3.18 **	-3.17 **	-2.97 **	-2.95 **
_1996	-5.06 **	-5.17 **	-5.24 **	-5.12 **	-4.56 **	-4.44 **	-4.40 **	-4.31 **
_1997	-4.94 **	-5.02 **	-5.05 **	-4.92 **	-4.71 **	-4.59 **	-4.68 **	-4.58 **
_1998	-3.49 *	-3.39 *	-3.90 **	-3.83 **	-3.49 **	-3.47 **	-3.63 **	-3.54 **
_1999	-2.92 **	-2.62	-1.77	-1.61	-1.59	-1.43	-1.87 *	-1.63
_2000	4.80 **	5.25 **	2.71 **	3.02 **	2.76 **	3.17 **	2.46 **	2.89 **
_2001	14.95 **	15.67 **	9.14 **	9.61 **	8.52 **	9.17 **	8.35 **	9.06 **
_2002	-2.70	-1.85	-3.98 **	-3.56 **	-3.27 **	-2.75 **	-3.55 **	-2.90 **
_2003	-0.69	-0.66	-0.89	-0.88	-0.49	-0.37	-0.99	-0.72
_2004	0.70	0.94	0.87	1.06	1.11	1.51	0.69	1.20
_2005	8.97 **	8.77 **	6.92 **	6.38 **	6.95 **	6.49 **	6.52 **	6.41 **
_2006	11.01 **	11.03 **	8.94 **	8.69 **	9.16 **	9.00 **	8.54 **	8.81 **
_constant	35.77 **	36.45 **	31.73 **	31.37 **	29.18 **	29.06 **	29.50 **	29.29 **
F-value	18.14	17.12						
Wald chi-square			883	880	1672	1616	1087	1043

RTO Years = # of years with all or nearly all of state included in RTO that conducted wholesale market operations.

RTO Pre-2003 = 1 only if all or nearly all of the state included in RTO that conducted wholesale market operations (years before 2003).

RTO Post-2002 = 1 only if all or nearly all of the state included in RTO that conducted wholesale market operations (years after 2002).

** significant @ 95% confidence level

* significant @ 90% confidence level

Table 4

Impact of Individual RTOs on Wholesale Electricity Prices ($/MWh)

	OLS fixed-effects		GLS		GLS w/ state fixed-effects		GLS w/ fixed-effects & autocorrelation correction	
	Costs	**Shares**	**Costs**	**Shares**	**Costs**	**Shares**	**Costs**	**Shares**
CAISO	16.03 **	14.83 **	21.16 **	15.28 **	16.37 **	15.87 **	13.01 *	12.72 *
ERCOT	1.59	1.38	8.50 **	2.56 *	3.11 *	2.97 *	4.03 *	3.98 *
ISONE	-5.45 **	-6.18 **	-1.52	0.27	-7.63 **	-7.33 **	-8.56 **	-8.49 **
MISO	1.55	1.94	1.95	1.73	2.74 *	2.70 *	2.12	2.17
NYISO	8.87 *	9.79 **	-4.79	-5.54	10.54 **	11.41 **	9.43	9.93 *
PJM	4.77 **	4.53 **	3.45 **	2.91 **	5.92 **	6.18 **	5.86 **	6.01 **
CoalCost	-2.92 *		9.07 **		-0.10		-0.23	
NGasCost	0.21		-0.17		0.08		0.09	
FuelOilCost	-1.04 **		-0.86 **		-0.49 **		-0.31	
NGasShare		7.29		20.30 **		15.47 **		10.48
FuelOilShare		16.22 *		18.31 **		11.87		5.10
NuclearShare	-16.45 **	-5.34	-0.67	15.15 **	-7.81	0.47	-12.05	-7.92
HydroShare	-21.35 *	-13.33	-2.42 *	1.19	-6.02	-0.31	-16.25 *	-12.77
F-value	15.76	15.72						
Wald chi-square			817	885	1727	1743	1112	1126

CAISO is CA from 1998; ERCOT is TX from 2001; NYISO is NY from 1999.

ISONE includes CT, MA, ME, NH, and VT from 1999 (RI excluded from all equations).

MISO includes IA, IN, MI, MN, ND, and WI in 2005 and 2006.

PJM includes DC, DE, MD, NJ, and PA from 1998; VA, WV from 2005.

** significant @ 95% confidence level

* significant @ 90% confidence level

Table 5

Impact of PJM/NYISO Membership on Wholesale Electricity Prices ($/MWh)

(Benchmark rates from Southeast states in Harvey study)

	GLS w/ state fixed-effects				GLS w/ fixed-effects & autocorrelation correction			
	Costs		**Shares**		**Costs**		**Shares**	
RTOMember	7.80	**	7.38	**	6.70	**	6.07	**
Wald chi-square	*898*		*743*		*595*		*512*	
RTO Years	1.35	**	1.26	**	1.26	**	1.20	**
Wald chi-square	*883*		*772*		*583*		*531*	
RTO Pre-2003	6.94	**	9.09	**	5.33	**	4.48	**
RTO Post-2002	8.75	**	6.19	**	7.97	**	8.37	**
Wald chi-square	*910*		*746*		*597*		*519*	
NYISO	15.58	**	16.38	**	13.00	**	14.17	**
PJM	6.37	**	6.15	**	5.90	**	5.29	**
Wald chi-square	*856*		*703*		*605*		*511*	

NYISO is NY from 1999.

PJM includes DC, DE, MD, NJ, and PA from 1998; VA, WV from 2005.

Traditional market states are AL, AR, FL, GA, NC and SC.

** significant @ 95% confidence level

* significant @ 90% confidence level

Table 6
Number of Electricity Wholesalers by State, 1999-2006

Year	1999	2000	2001	2002	2003	2004	2005	2006
AK		7	6	8	6	6	6	7
AL		4	4	8	4	4	4	4
AR		5	5	6	5	5	5	5
AZ		9	11	17	10	11	13	12
CA		36	37	150	47	46	47	45
CO		14	13	20	13	12	13	13
CT		9	8	28	8	6	6	7
DC		2	3	4	1	1	1	1
DE		2	2	3	2	2	3	3
FL		21	19	44	19	17	16	18
GA		9	10	19	10	8	8	8
HI		0	0	6	0	0	0	0
IA		41	41	49	37	38	39	38
ID		4	3	22	3	3	2	2
IL		16	13	27	11	9	9	9
IN		16	14	16	14	13	14	11
KS		24	24	23	21	19	16	18
KY		11	10	10	9	8	8	8
LA		11	10	18	8	8	8	8
MA		40	31	44	23	21	22	18
MD		5	5	23	3	3	0	1
ME		3	4	18	1	2	2	2
MI		15	15	39	16	16	17	16
MN		33	29	38	24	25	26	27
MO		33	35	33	30	33	31	32
MS		7	6	7	6	5	5	6
MT		6	6	11	6	7	7	6
NC		14	12	28	11	12	12	12
ND		8	8	7	7	8	8	8
NE		28	24	25	25	22	19	22
NH		5	5	9	5	4	3	4
NJ		6	3	18	1	1	1	1
NM		8	7	8	8	9	9	6
NV		5	5	12	5	5	5	5

Table 6, ctd.
Number of Electricity Wholesalers by State, 1999-2006

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
NY	18	19	58	17	16	16	14	15
OH	29	27	45	36	36	33	34	35
OK	15	16	16	13	13	13	12	10
OR	11	11	25	11	11	11	11	10
PA	21	19	45	17	15	14	14	12
RI	1	1	2	1	1	1	1	
SC	8	8	9	8	8	8	8	8
SD	10	10	8	9	9	9	9	9
TN	1	1	1	1	1	1	1	1
TX	58	51	82	49	48	53	49	46
UT	7	6	13	4	5	4	4	4
VA	8	6	14	5	5	5	5	7
VT	8	9	11	8	7	8	9	9
WA	22	24	40	24	22	21	22	21
WI	21	21	27	19	19	18	18	18
WV	1	1	2			1	1	1
WY	3	3	6	4	3	3	3	3
Total	**699**	**661**	**1,202**	**625**	**608**	**604**	**598**	**598**
RTOs since 99	***156***	***146***	***413***	***134***	***125***	***124***	***120***	***119***
non-RTO States	**324**	**315**	**473**	**298**	**292**	**282**	**287**	**283**

Source: Tabulations of EIA-861 data.

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