The Impact of Transparent Wholesale Markets on Market Participation: The Case of the U.S. Electricity Industry

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Coordination costs in a wholesale market are the need to determine the price and other parameters of the transaction, make the existence of buyers and sellers known to one another, and bring buyers and sellers together. The mitigation of coordination costs, all else equal, should increase participation in the marketplace. Since Federal Energy Regulatory Commission (FERC) Order 888 was issued in 1996, the trade in bulk electricity markets has increased significantly. In 1999 FERC issued Order 2000 to explore the role of regional transmission organizations in the restructured electricity marketplace. RTOs can reduce the coordination costs required to participate in the wholesale electricity markets, but also cause compliance costs to be incurred. Therefore, there are countervailing effects of these organizations on participation in the wholesale markets. This paper utilizes the diversity of the United States electricity market and a panel data set of electric utilities for the period 1990-2009 to study the effects that RTOs have had on the trade of wholesale electricity. The paper finds that the presence of a transparent wholesale marketplace for electricity has the effect of increasing participation, but that this participation does not occur symmetrically across all types of electric utilities. Greater participation is induced in privately-owned and larger utilities. These results have important implications for public policy aimed at increasing transparency in wholesale markets, and the organizations that facilitate it, as the opportunities afforded by this policy may not be uniformly distributed across all market participants.

I. Introduction

On December 20, 1999, the Federal Energy Regulatory Commission (FERC or "the Commission") issued Order No. 2000 in Docket No. RM99-2-000, a docket opened to explore the role of Regional Transmission Organizations (RTO) in the restructured electricity marketplace. The FERC noted that since FERC Order 888 was issued in 1996, trade in the bulk electricity markets had increased significantly. FERC also noted that during the Notice of Proposed Rulemaking process for the instant docket, the Commission had "reviewed evidence that traditional management of the transmission grid by vertically integrated electric utilities was inadequate to support the efficient and reliable operation that is needed for the continued development of competitive electricity markets, and that continued discrimination in the provision of transmission services by vertically integrated utilities may also be impeding fully competitive electricity markets."[1] FERC further enjoined utilities, state officials, and affected interest groups to voluntarily develop RTOs. Despite the urging of FERC, there remain substantial portions of the United States electricity grid that are not administered by RTOs or Independent System Operators (ISO).

Coase (1960) observed that there are costs involved in carrying out transactions in the market, such as "to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to the bargain, to draw up the contract …".[2] Milgrom and Roberts (1992) categorize these costs as either coordination or motivation costs. They define coordination costs as the need to determine the price and other parameters of the transaction, make the existence of buyers and sellers known to one another, and bring buyers and sellers together. Motivation costs arise from incomplete and asymmetric information and imperfect commitment. The wholesale market for electricity, where the relevant product is one kilowatthour (kWh) of electricity delivered to a particular location at one particular point in time, is prone to coordination costs, as the product has a very short useful life. RTOs and ISOs can have an explicit influence on the coordination costs in the wholesale electricity market, but the direction of that influence is not always clear. This paper employs a panel data set of United States electric utilities spanning the period 1990-2009 to investigate whether the existence of a transparent wholesale market increases the degree to which an electric utility participates in the wholesale market. I find that privately-owned utilities and larger utilities increase their participation in a transparent wholesale market, while participation of municipally-owned utilities is only slightly affected. This indicates that there are equity

[1]FERC Order 2000, issued December 20, 1999, Page 2 (89 FERC ¶ 61,285)
[2] Coase (1960) p. 15

considerations surrounding the establishment of ISOs and RTOs, as the distribution of benefits is not uniform across all market participants.

The remainder of the paper is organized as follows: Section II provides the theoretical basis for the investigation, Section III provides a review of related literature, Section IV describes the data utilized, Section V describes the empirical model and estimation methodology, Section VI reports the results of the estimation, and Section VII offers some concluding remarks.

II. Theoretical Basis

One way that ISOs and RTOs can influence the development of electricity markets is by providing a transparent wholesale market. Define a transparent wholesale market as one in which the prices for a unit of electricity delivered to a given location at a given point in time are posted in a manner that is easily accessible by any interested party, such as on a public web site.[3] Consider the case of a naive electric utility, Alpha, operating as an island, isolated from the electricity grid around it. The utility dispatches its generating units to supply electricity to its customers, and attempts to do so in a manner that optimizes performance, typically measured in terms of least cost or some standard of reliability. If electricity demand and the criteria under which the utility optimizes its portfolio (say, least cost) are taken as exogenous, then the utility's only decisions involve which of its generating units are dispatched at any given time. Alpha assesses the hourly marginal costs of its generating units, considers any constraints related to the units' availability or operating characteristics, determines how much electricity it must supply, and dispatches units sufficient to meet that demand at the least possible cost.

Now consider the existence of a second electric utility, Beta, physically interconnected to Alpha in a neighboring area. Operating as an island, Beta faces the same decision as Alpha.

[3] Per Bakos (1998). For an example from the Midwest ISO, see https://www.midwestiso.org/MARKETSOPERATIONS/REALTIMEMARKETDATA/Pages/LMPContourMap.aspx

However, if both utilities seek to minimize costs, and in a particular hour there is a difference between the utilities' marginal costs of generation that is greater than the cost of transmission from Beta to Alpha, then the opportunity for Pareto improvement exists. If Alpha has a higher marginal cost of generation than Beta in a given hour, then Beta can generate that marginal kWh and sell to Alpha at a price somewhere between their respective marginal costs, and both utilities have lowered their effective average costs of generation; Alpha by buying the marginal kWh at less than it would cost to generate it with its own units and Beta by realizing sales revenue greater than the cost to generate the marginal kWh.

But the costs that must be incurred in order to achieve this benefit are not limited to the cost of any transmission and the transaction itself. As seen in Milgrom and Roberts, there are also coordination costs. Each utility must expend resources to gather information about the electricity system around it. First, each must gather information regarding the number of potential trading partners. Second, each needs information regarding the costs and availability of electricity in any given hour, for every one of those potential trading partners, to determine whether an opportunity to trade exists. Third, each needs to know how to make the arrangements necessary to have that electricity delivered to the purchasing utility system in the event that a transaction is agreed upon. Before the advent of RTOs and ISOs, the first and third tasks were often performed by regional balancing authorities, organizations registered by the North American Electric Reliability Corporation (NERC) to integrate future resource plans, maintain the balance between load, interchange, and generation, and support real time interconnection frequency for a given area. The second function was accomplished primarily through bi-lateral contact between utilities, though confederations of utilities also existed. For example, before ISOs and RTOs existed, the Orlando Utilities Commission, the City of Lakeland, and the Florida

Municipal Power Agency formed the Florida Municipal Power Pool in 1988 to centrally commit and dispatch all of the pool members' generating resources to meet the pool's load obligations in the most economical manner.

By establishing a transparent wholesale market place, however, the RTO can fulfill the second task for the utility, either by maintaining a centralized databank of hourly prices, or by collecting hourly bids and offers from utilities interested in participating in the market. While the RTO can lower the costs required to gather this information, other costs to participate in this market still exist. Utilities must incur costs in order to conform to the rules and procedures of this wholesale market, and the ability to trade with utilities that are members of other RTOs may be constrained. In a survey of RTO cost/benefit studies, Eto, Lesieutre, and Hale (2005) report that while utilities will incur costs to participate in these markets, these costs had not been explicitly studied. Additionally, Newell and Spees (2011) find that gaps in realized sales of capacity across the PJM/MISO seam are caused by institutional barriers. These barriers include difficulty in obtaining long term firm transmission service to support capacity sales, and energy market must-offer requirements that impose risks on capacity importers. Therefore, there are countervailing factors that may influence the utility's willingness to participate in this wholesale market.

III. Related Literature

The majority of the existing literature on electricity market restructuring has focused on the impacts of the restructuring itself. Kwoka (2006) reviews a number of studies on the price effects of electricity restructuring, and finds that they are plagued by the endogeneity of the treatment variable, electric restructuring, as the states with higher prices tended to restructure their electric industry. He also finds that it is difficult to disentangle the two effects of restructuring, the change in market structure and the effects of the rate agreements, or artificial price controls, necessary to implement restructuring. Fabrizio, Rose, and Wolfram (2007) examine the effects on restructured markets on electric generators and find increases in operating efficiency through reductions in labor and nonfuel operating expenses. Kwoka, Pollitt, and Sergici (2010) study electric distribution systems and find that forced divestiture as a result of electric restructuring has resulted in decreases in efficiency in distribution. Hogan (1995) argues that the ISO must be actively involved with the operation of the wholesale market and the problem of system dispatch. However, little empirical work has been done to assess the benefits of the RTOs and ISOs themselves, although PJM Interconnection and the Midwest ISO have published their own studies on their benefits to consumers. Outside of the electricity industry, Garicano and Kaplan (2000) have studied the changes in transaction costs as a result of business-to-business e-commerce and find that the Internet reduces coordination costs.

This study follows earlier work (Kury 2011) that examined the retail price effects of RTOs and ISOs in the United States electricity market. That work concluded that ISOs and RTOs did not have a significant effect on retail prices, once the confounding effects of electric restructuring were removed from the data. However, that work acknowledges that while lower prices are a stated goal of the FERC, they are not the only benefit of establishing these organizations. Chandley and Hogan (2009) point out that "… part of the purpose of RTO design was to facilitate trading …"[4], and show that the day ahead net exports from the Midwest to the PJM region tripled when American Electric Power became a member of PJM in October of 2004.[5] FERC Order 2000 identified five benefits that RTOs can offer: improved efficiencies in the management of the transmission grid, improved grid reliability, non-discriminatory transmission practices, improved market performance, and lighter-handed government

[4] Chandley and Hogan (2009), Page 33
[5] Chandley and Hogan (2009), Page 34

regulation.[6] This study examines whether utilities increase their participation in the wholesale markets for electricity generators and electricity providers, either due to improved efficiencies in grid management or non-discriminatory transmission practices.

IV. Data

The primary data source for the model is the Form 861 database compiled by the U.S. Department of Energy's Energy Information Administration. The reporting of information collected on the Form 861 is an annual requirement for all privately and publicly owned electric utilities in the United States and its territories. Data collected includes the quantity of wholesale and retail purchases and sales, revenues, number of customers, annual system peak load, as well as information on demand-side management programs, green pricing and net metering programs, and distributed generation capacity. The utilities also report their control area operator on the form, which allows the identification of the time periods during which the utility is a part of an RTO that has established a transparent wholesale market. Total sources and disposition of energy on the form is disaggregated into several categories that are important for this study. Data includes the annual generation for each utility, net of the plant's own use (reported as net generation), and purchases from the wholesale market (reported as purchases). Together, these accounts are aggregated as total electricity sources for the utility. The total sources of electricity in a given year must always equal the total disposition of electricity, which is disaggregated into sales to ultimate consumers (retail sales), sales for resale (wholesale sales), and electricity losses (losses due to the transmission or distribution of electricity).

The data set consists of over 64,000 data points, each representing the response of one electric utility for one year from 1990 through 2009. This data set is an unbalanced panel, with roughly 3000 to 4000 utilities responding in any given year. However, these utilities enter and

[6] FERC Order 2000, issued December 20, 1999, Page 70-71 (89 FERC ¶ 61,285)

exit the sample in a non-random fashion, and the inclusion of all utilities in the sample can lead to selection bias (Heckman 1979). Therefore, this analysis employs a balanced panel, only those utilities which have submitted data over the entire 20 year data collection period.

The questions of whether utilities purchase more electricity or sell more electricity in the wholesale markets, in the presence of an RTO, will be addressed separately. For the initial purchase sample, only utilities with positive sales to ultimate consumers, that is, utilities which serve retail electric load are considered. Utilities that do not themselves generate electricity in any year of the sample are excluded from this sample. These utilities are likely 'all requirements customers'[7] of another utility, and therefore lack the means to serve their electric load, except by purchasing electricity on the wholesale market. These utilities would therefore be unaffected by the presence of a transparent wholesale market because they are restricted to purchasing 100% of their electricity regardless of whether the wholesale market is transparent. The dependent variable for this sample is the fraction of the total sources of energy that is purchased from the wholesale market. The naïve utility Alpha in the initial example would purchase none of its energy requirements in the wholesale market, and its participation in the market may be limited by the coordination costs. As these coordination costs change, the utility may find it beneficial to participate in the market. Initially, the utility may only participate in the market when necessary (i.e. when it has insufficient generation to meet its needs, perhaps due to unit outages), and the percentage of its energy that it purchases in the wholesale market may be very low. However, as coordination costs evolve, the utility may also look for economic opportunities to displace its own generation with market purchases, thus increasing the percentage of its requirements that it purchases. In this manner, the dependent variable might change for each utility over time with

[7] These are utilities that serve retail electricity customers but purchase all of the electricity required to serve them on the wholesale market.

changes in coordination costs. Participation could also be measured by the volume of wholesale purchases, but this would be expected to increase as the electricity requirements of the utility grow. Normalizing these purchases by the total sources of electricity removes this potential bias.

Similarly, the initial sales sample includes all utilities with positive net electricity generation in a given year, with the exception of any utility that sold all of that generation in the wholesale market over the entire time period in the study. These utilities are likely wholesale generators, and the presence of a transparent wholesale market will have no effect on whether they participate in the wholesale market. The dependent variable in this case is the fraction of total disposition of energy that is sold on the wholesale market.

Broader criteria may be used to derive the samples, however. Recall that the initial purchase sample excluded any utility that did not generate electricity in any year during the sample period. However, a transparent wholesale marketplace might afford utilities that do not generate electricity the opportunity to purchase electricity not needed to serve retail load, and then resell that electricity to another retail provider. Utilities that exploit this opportunity in the wholesale market are excluded from the initial sample, but the presence of a transparent wholesale market may still influence their behavior. Therefore, the second purchase sample includes any utility in the initial purchase sample, as well as utilities that reported sales for resale during the sample period. This sample is much larger, and affords the opportunity to use the majority of the data points. Similarly, the second sales sample encompasses generating utilities that serve ultimate consumers during some period during the sample. Unlike the broader purchase criteria, this does not lead to a sizable increase in the portion of the sample used.

V. Model

The model to be estimated is the dependent variable (*DV*), which is either the fraction of the total sources of energy that comes from the wholesale market (for the Purchase regressions), or the fraction of total disposition of energy that is sold on the wholesale market (for the Sale regressions).

$$DV_{it} = \alpha_i + \beta_0 MktUtils_t + \beta_1 Time + \beta_2 ISO\_Whl_{it} + \beta_3 ISOYrs_{it} + \beta_4 ISOYrs_{it}^2 + \beta_5 SumPk + \beta_6 Federal_i + \beta_7 Muni_i + \beta_8 IOU_i + \beta_9 SumPkxISO + \beta_{10} MunixISO + \beta_{11} IOUxISO + \beta_{12} SumPkxISOYrs + \beta_{13} SumPkxISOYrs^2 + \beta_{14} MunixISOYrs + \beta_{15} IOUxISOYrs + \beta_{16} IOUxISOYrs^2 + \varepsilon_{it}$$

Changes in the dependent variable are explained by a utility-specific fixed effect, the number of utilities that exist in the 48 contiguous United States in the given year (*MktUtils*), a linear time trend (*Time*), an indicator variable equal to 1 if the utility is a member of an RTO that operates a transparent wholesale market in that year (*ISO_Whl*), the number of years that the utility has been in a transparent wholesale market (*ISOYrs*), the size of the utility measured by its summer peak demand (*SumPk*), and indicator variables equal to 1 depending on the ownership of the utility (*Federal* if it is a federal power project, *Muni* if a municipally-owned utility, and *IOU* if a privately-owned utility). Our variables of interest include the *ISO_Whl* and *ISOYrs* variables, as well as the interaction between these variables and the size and ownership variables. Descriptive statistics for the purchase samples are given in Table 1, and the sales samples in Table 2.

Table 1: Mean and Standard Deviation of Purchase Sample

	All	Purch1	Purch2
Purchase%	0.9297 0.2136	0.8335 0.2942	0.9419 0.1911
MktUtils	3230.8 213.4	3217.8 190.7	3217.8 190.7
ISO_Whl	0.1458 0.3560	0.1623 0.3688	0.1436 0.3507
ISOYrs	0.6127 1.7849	0.7317 2.0041	0.6061 1.7818
SumPk	281.16 2765.44	634.86 2491.64	266.04 2821.21
Federal	0.0022 0.0471	0.0048 0.0694	0.0020 0.0453
Muni	0.5873	0.7299	0.6367

	0.4923	0.4440	0.4809
IOU	0.0612 0.2397	0.1339 0.3406	0.0528 0.2237
N	61370	19405	55484

Table 2: Mean and Standard Deviation of Sales Sample			
	All	Sales1	Sales2
Sales%	0.1567 0.3239	0.2284 0.3452	0.2583 0.3697
MktUtils	3277.0 265.9	3217.8 190.7	3217.8 190.7
ISO_Whl	0.2231 0.4164	0.1480 0.3551	0.1510 0.3581
ISOYrs	0.9561 2.1612	0.6359 1.8277	0.6551 1.8607
SumPk	463.74 2016.93	1081.18 3027.79	1056.29 2982.65
Federal	0.0045 0.0671	0.0134 0.1148	0.0129 0.1127
Muni	0.5701 0.4951	0.6231 0.4846	0.6061 0.4886
IOU	0.0997 0.2997	0.2066 0.4049	0.2137 0.4099
N	35784	9819	10165

Notable by its absence from the data set is the utility’s cost relative to the costs of other utilities in its area. This variable is especially notable because it is the catalyst for the interaction in the hypothetical example of utilities Alpha and Beta. However, hourly wholesale price data is not available for utilities that do not participate in transparent wholesale markets, the control group for this study. Absent this data, the effect of cost differentials could be modeled with a variety of annual aggregated regional price differentials, such as mean and maximum differentials, but none of the coefficients on these variables proved to be significant at any reasonable level. Moreover, the relatively high R^2 values in the regressions suggest that the explanatory power of any omitted variables is relatively small.

The treatment effect in the model, whether the utility is a member of an organization that operates a transparent wholesale market, might be seen as endogenous, but it important to note that membership in an RTO or ISO is mandatory for any utility located in a state that restructured its electricity market, and that the decision to restructure the market was made by the state legislatures, and not the utility itself. Further, utilities that operate within the control area of a larger utility may find themselves compelled to join an RTO if their control area operator does so. Finally, as argued in Kwoka (2006), price is often cited as the decision to initiate changes in the electricity market, not purely participation in the market itself. However, additional analyses are performed in this paper with a sample free from endogeneity concerns, and the basic results still stand.

The utility specific fixed effect accounts for the fact that utilities serve their load obligations with different combinations of owned generation and purchased power. Due to the long-lived nature of generating assets, this fixed effect will simply reflect the average purchases and sales of the utility over time, and will be relatively stable. The Market Utilities variable is expected to be positive, as the liquidity of the market should increase as more utilities are participating in it. The remaining variables are the variables of interest, although the null hypothesis suggests that the effects of the constraints imposed by the transparent wholesale markets would be less than the effects of the cost reduction of the information regarding electricity availability and price, and that the coefficients on these variables will be positive. A variable to track how long the utility has been involved with a transparent wholesale market is also included, to discern whether the length of time that utilities have been exposed to this market changes the degree to which they participate.

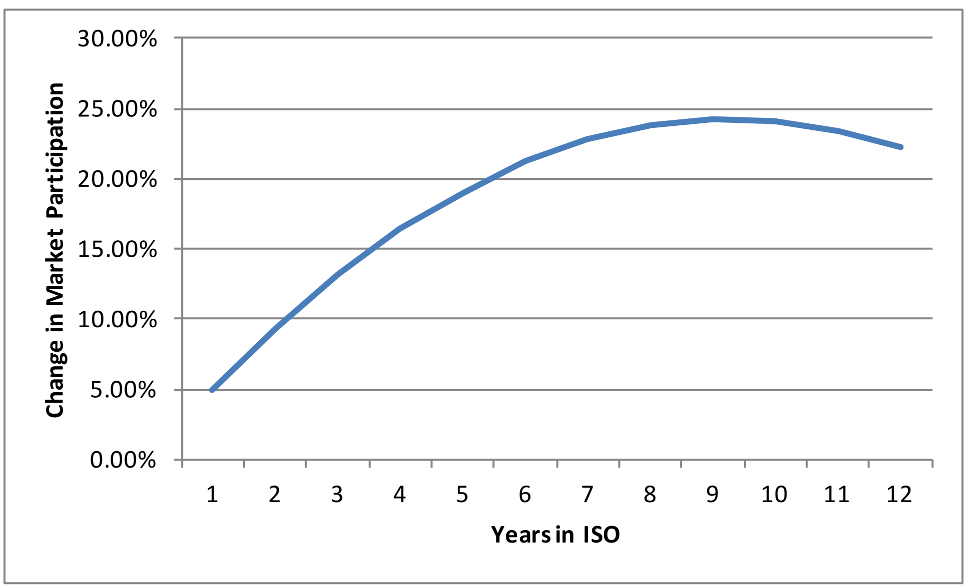
VI. Results

The results of the estimation with the initial sample are given in Table 3.

Table 3: Parameter Estimates for Initial Sample		
Variable	**% Purchased**	**% Sold**
Average Fixed Effect	0.7017*** (0.0583)	0.1004*** (0.0231)
MktUtils	1.63e-05*** (3.90e-06)	2.98e-05*** (7.04e-06)
Time	0.0032*** (0.0004)	0.0018*** (0.0004)
ISO_Whl	-0.0192 (0.0198)	-0.0034 (0.0160)
ISOYrs	-7.24e-06 (5.09e-02)	-4.68e-03 (7.78e-03)
ISOYrs^2	0.0001 (0.0004)	-4.71e-04 (5.63e-04)
SumPk	-1.01e-06 (2.06e-06)	-1.17e-06*** (3.81e-07)
Federal	-0.3968*** (0.0040)	
Muni	0.0553 (0.0774)	0.0143 (0.0269)
IOU	0.0292*** (0.0040)	0.0164*** (0.0035)
SumPk x ISO_Whl	1.17e-05* (7.10e-06)	-3.59e-06 (2.42e-06)
Muni x ISO_Whl	0.0151 (0.0200)	-0.0046 (0.0133)
IOU x ISO_Whl	0.0403 (0.0447)	0.0691** (0.0323)
SumPk x ISOYrs	-2.34e-06 (1.89e-06)	8.11e-07 (9.78e-07)
SumPk x ISOYrs^2	3.93e-07** (1.51e-07)	-1.12e-07 (1.17e-07)
Muni x ISOYrs	-0.0070** (0.0035)	0.0064 (0.0045)
IOU x ISOYrs	0.0521*** (0.0170)	-0.0089 (0.0144)
IOU x ISOYrs^2	-0.0028** (0.0013)	0.0020* (0.0012)
N	19405	9819
Number of clusters (utilities)	980	524
R-squared	0.8736	0.9532
(Robust standard errors clustered by utility in parentheses) * Statistically significant at the 10% level ** Statistically significant at the 5% level *** Statistically significant at the 1% level		

The average fixed effect represents the average purchases or sales of the utilities in the wholesale market, and is, as expected, positive and statistically significant. The number of utilities in the market also has a positive and significant effect on the fraction of wholesale purchases and sales for the utilities, but the magnitude of the effect is not large. The coefficient implies that an additional 1000 utilities, increasing the market size by approximately 25%, would result in an extra 1.5% in purchases or 3% in sales. Since the relevant product in the wholesale electricity market is a kWh of electricity delivered to a particular location, the presence of an additional utility near Cleveland, say, would likely have little effect on the degree of market participation of a utility near Los Angeles, and this effect is reflected in the magnitude of this coefficient. It appears, from the time trend, that utilities have been purchasing about 0.3% more and selling about 0.2% more electricity in the wholesale market every year. The presence of a wholesale market alone has a negative, but insignificant effect on market participation. This may indicate that the barriers imposed by these markets may make it more difficult to sell electricity, but the effect is not statistically different from zero. The number of years exposed to the wholesale market does not have a statistically significant effect, but does when interaction terms are considered. The coefficient on the size of the utility indicates that larger utilities have a tendency to sell less electricity. However, the magnitude of this effect on sales is very small. For a utility with a peak demand of 1000 MW, for example, slightly smaller than the utility in Knoxville, Tennessee, the effect on sales would be -0.1%. The ownership indicators are only significant for the federally-owned and privately-owned utilities, indicating that the federal utilities purchase much less than other utilities, on average, and that privately-owned utilities both purchase and sell more. The coefficient on federal utilities is not surprising, as most were established as electricity generators. The interaction terms are far more interesting. They indicate that municipally-owned utilities increase their purchases from a transparent wholesale market by approximately 1.5%, but this result is not significantly different from zero. However, they also show that municipal utilities decrease their purchases from the transparent wholesale market by 0.7% per year, and this result is statistically significant at the 5% level. This may occur if the transactions costs of the market are not fully understood, but more information regarding their magnitude is gained over time[8]. Meanwhile, privately-owned utilities participate in the markets to a much greater degree, increasing their sales by 6.9%. The length of time that a privately-owned utility is exposed to the transparent wholesale market also affects its participation. The coefficients for the purchase sample imply the relationship shown in Figure 1.

Figure 1: Effect of the IOUxISOYrs and IOUxISOYrs2 Coefficients on Wholesale Market Purchases of the Initial Sample



While the magnitude of the coefficients imply that the effect on participation will eventually become negative, it is important to realize that this point, sometime in the 19th year, is beyond the time horizon of the sample. Transparent wholesale markets have only existed in the

[8] For example, on April 25, 2006, FERC ordered MISO to recalculate revenue sufficiency guarantee charges retroactive to May 1, 2005, as a result of the misapplication of their tariff. (115 FERC ¶61,108)

sample for 12 years, so these coefficients may not reflect the nature of this relationship over a longer period of time. It is clear that, in the time frame of this analysis, experience in the markets increases participation at a decreasing rate. Similarly, the coefficients for privately-owned utilities in the sales sample, and larger utilities in the purchase sample, imply that market participation increases at an increasing rate within the time period of study sample, but this behavior cannot be expected to continue indefinitely.

So, while the effect of transparent wholesale markets on municipal utilities is statistically insignificant, larger utilities and privately-owned utilities seem to participate more in a transparent whole market. These broad results are similar in concept to the results of Rose and Joskow (1990) who concluded that larger utilities and privately-owned utilities adopted new gas-fired generating technologies sooner than smaller and municipally-owned utilities. In this instance, the creation of a transparent wholesale electricity market can be seen as the technological innovation being adopted by the utilities.

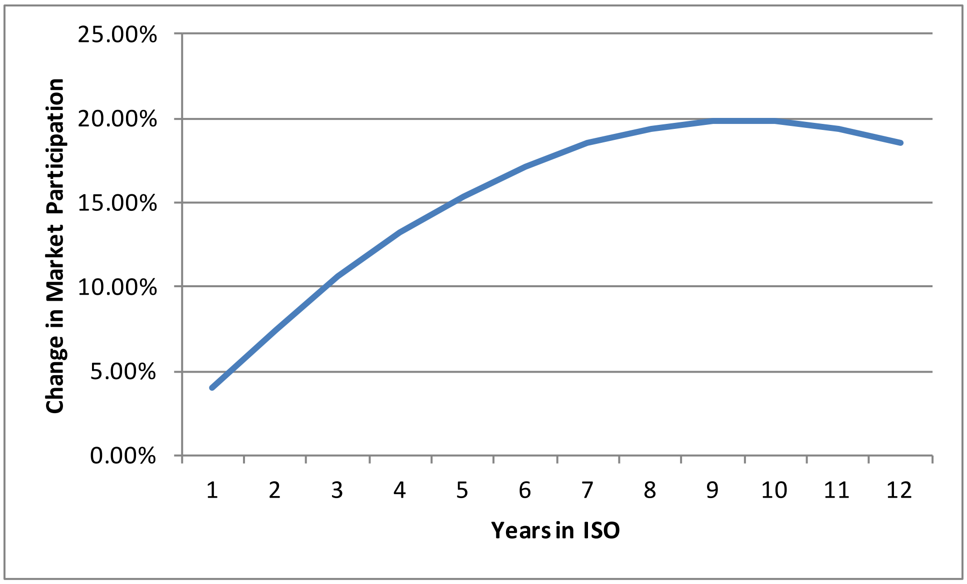
Estimating the regression for the expanded sample changes the coefficients, but does not change the basic results, as shown in Table 4. Recall that this expended sample includes utilities that may not own generation themselves, but purchase electricity in excess of the needs of their customers to resell on the wholesale market. Therefore, the average fixed effect for purchases increases by approximately 20%. The effect of the wholesale market variable is negative, but only statistically significant for purchases. The time trend is still positive and significant, but smaller in magnitude. The presence of the market itself decreases purchases by 0.7%. Again, larger utilities decrease participation in the wholesale markets, with the sales for a 1000 MW utility decreasing about 1.1%. Municipal utilities exhibit a similar pattern to the initial sample, with an initial increase in purchases, and a subsequent decrease over time, but now the statistical significance of those effects are reversed. The initial increase of 0.7% is significant, while the experience trend is not. Larger utilities again exhibit a quadratic increase in purchases, to the temporal limit of our sample.

Table 4: Parameter Estimates for Expanded Sample		
Variable	**% Purchased**	**% Sold**
Average Fixed Effect	0.9008*** (0.0364)	0.1342*** (0.0212)
MktUtils	5.73e-06*** (1.40e-06)	2.79e-05*** (6.71e-06)
Time	1.07e-03*** (1.39e-04)	0.0017*** (0.0004)
ISO_Whl	-7.74e-03** (3.30e-03)	-0.0049 (0.0147)
ISOYrs	-9.65e-04 (1.53e-03)	-0.0035 (0.0072)
ISOYrs^2	4.54e-05 (1.40e-04)	-4.98e-04 (5.48e-04)
SumPk	-2.43e-08 (1.11e-07)	-1.17e-06*** (3.79e-07)
Federal	-0.3749*** (0.0014)	
Muni	0.0207 (0.0548)	0.0114 (0.0023)
IOU	-0.0504 (0.0536)	-0.0160*** (0.0034)
SumPk x ISO_Whl	1.16e-05* (6.96e-06)	-3.03e-06 (2.31e-06)
Muni x ISO_Whl	7.68e-03** (3.83e-03)	-0.0034 (0.0120)
IOU x ISO_Whl	0.0378 (0.0323)	0.0644** (0.0312)
SumPk x ISOYrs	-1.52e-06 (1.99e-06)	5.52e-07 (9.36e-07)
SumPk x ISOYrs^2	3.79e-07** (1.51e-07)	-7.95e-08 (1.00e-07)
Muni x ISOYrs	-0.0018 (0.0011)	0.0056 (0.0039)
IOU x ISOYrs	0.0418*** (0.0132)	-0.0078 (0.0138)
IOU x ISOYrs^2	-0.0022** (0.0010)	0.0017 (0.0011)

N	55484	10165
Number of clusters (utilities)	2802	544
R-squared	0.8839	0.9578
(Robust standard errors clustered by utility in parentheses) * Statistically significant at the 10% level ** Statistically significant at the 5% level *** Statistically significant at the 1% level		

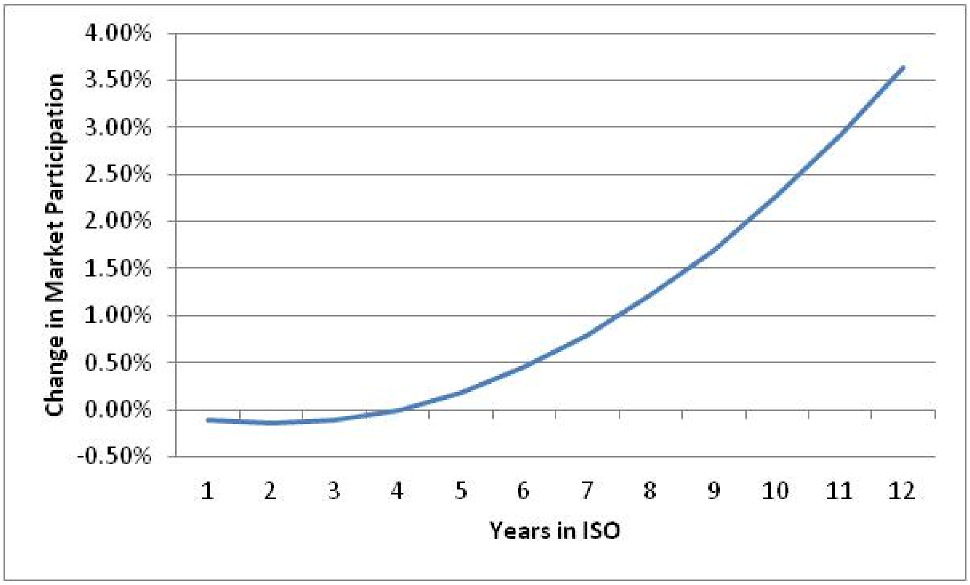
The pattern for privately-owned utilities is similar as well. The coefficients for market experience imply the relationship in Figure 2, but it is still important to consider the temporal limits of the sample. Finally, the effect on market participation for municipal utilities is very small, and the effect for larger and privately-owned utilities is large.

Figure 2: Effect of the IOUxISOYrs and IOUxISOYrs2 Coefficients on Wholesale Market Purchases of the Expanded Sample



Relative to the ownership status of the utility, the size of the utility has a smaller effect on the degree of market participation. Figure 3 shows the effect of the interaction between the size of the utility and its experience in an ISO. These coefficients are from Table 4 and illustrate the change in market purchases for a 1000 MW utility. Note that for the first four years, the effect is nearly zero, but increases thereafter. But even at 12 years of experience, the utility's peak load would have to be 6000 MW, roughly the size of the City of Los Angeles, for the magnitude of the size and experience effect to be equivalent to the privately-owned utility experience effect.

Figure 3: Effect of the SumPkxISOYrs and SumPkxISOYrs2 Coefficients on Wholesale Market Purchases of a 1000MW Utility in the Expanded Sample



As discussed earlier, the dependent variable for market participation could be thought of as endogenous. In order to evaluate whether this endogeneity might have an effect on the results, the estimation can be repeated using only states that restructured their electricity industry. This restructuring enabled by FERC, and initiated by state legislatures, and required utilities to either relinquish their assets, or the control of their assets, to a third party. Thus, utilities in restructured states that joined RTOs did so not of their own accord, but because they were compelled by the legislature. As discussed in Kwoka (2006), the motivation for states to restructure was high electricity prices, and not the dependent variable in this analysis, so a sample of restructured states should be free of these endogeneity concerns. The results of this estimation are shown in Table 5.

Table 5: Parameter Estimates for Expanded Sample: Utilities in States that Restructured their Electricity Industry		
Variable	**% Purchased**	**% Sold**

Average Fixed Effect	0.8463 *** (0.0252)	0.1235*** (0.0414)
MktUtils	1.46e-05*** (4.72e-06)	3.64e-04** (1.21e-05)
Time	2.58e-03*** (5.45e-04)	0.0041*** (0.0012)
ISO_Whl	-6.90e-03 (6.24e-03)	-0.0126 (0.0251)
ISOYrs	-4.98e-03** (2.18e-03)	-0.0109 (0.0105)
ISOYrs^2	2.74e-04 (1.77e-04)	-3.31e-05 (8.40e-04)
SumPk	6.81e-07 (1.12e-06)	-1.44e-06*** (3.04e-07)
Muni	-2.18e-05 (7.27e-02)	0.0675 (0.0824)
IOU	-0.1285 (0.0894)	
SumPk x ISO_Whl	1.96e-05*** (7.26e-06)	-8.93e-06* (5.17e-06)
Muni x ISO_Whl	1.94e-03 (6.68e-03)	-0.0024 (0.0186)
IOU x ISO_Whl	0.0486 (0.0452)	0.0995* (0.0575)
SumPk x ISOYrs	-3.39e-06 (2.58e-06)	1.79e-06 (1.92e-06)
SumPk x ISOYrs^2	4.31e-07** (1.83e-07)	-2.07e-07 (1.43e-07)
Muni x ISOYrs	-0.0017 (0.0013)	0.0065 (0.0044)
IOU x ISOYrs	0.0585*** (0.0176)	-0.0110 (0.0221)
IOU x ISOYrs^2	-0.0034*** (0.0012)	0.0023 (0.0015)
N	13361	3071
Number of clusters (utilities)	686	173
R-squared	0.8525	0.9298
(Robust standard errors clustered by utility in parentheses) * Statistically significant at the 10% level ** Statistically significant at the 5% level *** Statistically significant at the 1% level		

The coefficients in Table 5 differ from those in Table 4, but the basic results of the analysis remain. Market participation in the purchase market tends to increase for larger utilities and privately-owned utilities. Municipal utilities, controlling for size, do not realize statistically significant changes in their degree of market participation. In the sales market, privately-owned utilities tend to sell about 10% more, but this result is only significant at the 10% level. Larger utilities tend to sell less, but the amount is small in magnitude. Thus, the potential endogeneity of the dependent variable is not driving the results of the analysis.

Since the results for restructured states are consistent with those for the entire sample, this might beg for the question of whether restructuring is solely responsible for the results. To test whether this is true, the estimation can be repeated using the complement of the data set in Table 5, just those states that did not restructure their electricity industry. In this model specification, the squared terms associated with the number of years in the ISO, and the interaction of this variable with the size of the utility and the ownership status, become statistically insignificant. The model is estimated with those terms removed, and the results of this estimation are shown in Table 6.

Table 6: Parameter Estimates for Expanded Sample: Utilities in States that did not Restructure their Electricity Industry

Variable	**% Purchased**	**% Sold**
Average Fixed Effect	0.9888*** (0.0038)	0.1538*** (0.0180)
MktUtils	2.34e-06** (1.11e-06)	1.81e-05*** (5.38e-06)
Time	8.22e-04*** (1.25e-04)	0.0010*** (0.0003)
ISO_Whl	-3.72e-03** (1.70e-03)	1.45e-03 (5.08e-03)
ISOYrs	-1.54e-03** (6.10e-04)	-9.07e-04 (7.97e-04)
SumPk	-5.35e-08 (1.15e-07)	1.59e-06 (1.73e-06)
Federal	-0.3723*** (0.0013)	
Muni	-0.0827*** (6.74e-05)	-0.0011 (0.0054)
IOU	0.0044***	0.0093***

	(0.0010)	(0.0028)
SumPk x ISO_Whl	-1.17e-06 (8.01e-06)	-2.39e-06 (1.63e-06)
Muni x ISO_Whl	4.21e-03 (4.33e-03)	0.0047 (0.0110)
IOU x ISO_Whl	0.0576** (0.0286)	0.0509* (0.0268)
SumPk x ISOYrs	4.81e-06 (3.41e-06)	2.83e-07 (2.95e-07)
Muni x ISOYrs	4.17e-05 (1.18e-04)	-0.0017 (0.0029)
IOU x ISOYrs	-2.85e-04 (1.06e-02)	-0.0100 (0.0070)
N	42123	7094
Number of clusters (utilities)	2137	390
R-squared	0.9201	0.9782
(Robust standard errors clustered by utility in parentheses) * Statistically significant at the 10% level ** Statistically significant at the 5% level *** Statistically significant at the 1% level		

With this specification, the market participation effect of the size of the utility becomes statistically insignificant, but the ownership effect remains. The privately-owned utilities located within ISOs buy approximately 5.8% more electricity and sell approximately 5.1% more electricity than they do outside of ISOs. Municipally-owned utilities see no statistically significant change in their market behavior.

Finally, to test whether the results are driven by the relationship between municipally-owned utilities and privately-owned utilities, the participation equations can be separately estimated with each subsample. The results of these estimations are shown in Table 7 and Table 8.

Table 7: Parameter Estimates for Expanded Sample: Municipal Utilities		
Variable	**% Purchased**	**% Sold**
Average Fixed Effect	0.9459*** (0.0051)	0.0114 (0.0279)

MktUtils	3.14e-07 (1.50e-06)	1.93e-05** (8.37e-06)
Time	1.11e-03*** (1.65e-04)	1.27e-03*** (4.17e-04)
ISO_Whl	-1.63e-03 (3.32e-03)	-0.0108 (0.0072)
ISOYrs	-1.97e-03 (1.62e-03)	0.0057 (0.0042)
ISOYrs^2	-4.50e-05 (1.67e-04)	-8.86e-04** (3.95e-04)
SumPk	-2.60e-05 (1.74e-05)	3.25e-06 (9.55e-06)
SumPk x ISO_Whl	4.22e-05** (1.88e-05)	-2.05e-05 (1.59e-06)
SumPk x ISOYrs	-1.95e-05* (1.10e-05)	1.30e-05 (8.70e-06)
SumPk x ISOYrs^2	2.53e-06* (1.38e-06)	-1.12e-06 (9.37e-07)
N	35256	6047
Number of clusters (utilities)	1785	338
R-squared	0.8567	0.9293
(Robust standard errors clustered by utility in parentheses) * Statistically significant at the 10% level ** Statistically significant at the 5% level *** Statistically significant at the 1% level		

Table 8: Parameter Estimates for Expanded Sample: Investor Owned Utilities		
Variable	**% Purchased**	**% Sold**
Average Fixed Effect	0.0918 (0.0651)	0.0578 (0.0515)
MktUtils	9.98e-05*** (1.69e-05)	5.91e-05*** (1.49e-05)
Time	0.0106*** (0.0020)	0.0040*** (0.0012)
ISO_Whl	-0.0486 (0.0342)	0.0517 (0.0339)
ISOYrs	0.0313** (0.0143)	-0.0126 (0.0149)
ISOYrs^2	-0.0018* (0.0010)	1.12e-03 (1.03e-03)
SumPk	-7.37e-06 (6.74e-06)	-4.89e-06 (3.83e-06)

SumPk x ISO_Whl	1.90e-05** (7.79e-06)	-5.01e-06 (3.46e-06)
SumPk x ISOYrs	-1.68e-06 (2.65e-06)	4.26e-07 (1.70e-06)
SumPk x ISOYrs^2	3.46e-07* (1.83e-07)	-4.93e-08 (1.34e-07)
N	2908	2248
Number of clusters (utilities)	151	117
R-squared	0.8153	0.8454
(Robust standard errors clustered by utility in parentheses) * Statistically significant at the 10% level ** Statistically significant at the 5% level *** Statistically significant at the 1% level		

The only significant result in the sales market is a decrease in participation with experience for the municipal utilities. In the purchase market, participation tends to increase for municipal utilities as the size of the utility increases. This basic result is consistent with the earlier results. For the privately-owned utilities, experience in an ISO increases participation at a decreasing rate, consistent with the earlier results. And once again, participation in the purchase market increases with the size of the utility. So while the coefficients may change, the basic results of the analysis remain the same, robust to different samples and model specifications.

VII. Conclusions

It is clear that RTOs and ISOs can provide opportunities in the electricity market that might not otherwise exist. One such opportunity is the facilitation of the transparent wholesale electricity market. Transparent wholesale markets can reduce coordination costs that limit the participation of utilities in the marketplace, and thus limit opportunities that might arise with that participation. However, also impose costs that may discourage participation in the wholesale market. This paper estimates some determinants of market participation, and shows that the presence of a transparent wholesale marketplace for electricity has the effect of increasing participation in the wholesale market, but that this participation does not occur symmetrically across all types of electric utilities. Greater participation is induced in privately-owned and larger utilities, mirroring the results of Rose and Joskow, who found that privately-owned and larger electric utilities are more willing to adopt technological innovations in the industry. These results have important implications for public policy aimed at increasing transparency in wholesale electricity markets, and the organizations that facilitate it, as the opportunities afforded by this policy may not be uniformly distributed across all market participants.

References

Bakos, Yannis. 1998. “The Emerging Role of Electronic Marketplaces on the Internet”, *Communications of the ACM* Vol. 41, No. 8 (1998), pp. 35-42.

Chandley, John and William W. Hogan. 2009. “Electricity Market Reform: APPA’s Journey Down the Wrong Path”. Report Prepared by LECG (April 16, 2009)

Coase, Ronald. 1960. “The Problem of Social Cost”, *Journal of Law and Economics* Vol. 3 (Oct., 1960), pp. 1-44.

Eto, Joseph H., Bernard C. Lesieutre, and Douglas R. Hale. 2005. “A Review of Recent RTO Benefit-Cost Studies: Toward More Comprehensive Assessments of FERC Electricity Restructuring Policies”, Report Prepared for Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy.

Fabrizio, Kira R., Nancy L. Rose, and Catherine D. Wolfram. 2007. “Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency”, *American Economic Review* Vol. 97, No. 4 (2007), pp. 1250-1277.

Garicano, Luis and Steven N. Kaplan. 2000. “The Effects of Business-To-Business E-Commerce on Transaction Costs”, *NBER Working Paper 8017*.

Heckman, James J. 1979. “Sample Selection Bias as a Specification Error”, *Econometrica*, Vol. 47, No. 1 (1979), pp. 153-161.

Hogan, William W. 1995. “A Wholesale Pool Spot Market Must Be Administered by the Independent System Operator: Avoiding the Separation Fallacy”. *The Electricity Journal*, December 1995, pp.26-37.

Kwoka, John. 2006. “Restructuring the U.S. Electric Power Sector: A Review of Recent Studies”, Report Prepared for the American Public Power Association.

Kwoka, John, Michael Pollitt, and Sanem Sergici. 2010. “Divestiture Policy and Operating Efficiency in U.S. Electric Power Distribution”. *Journal of Regulatory Economics* 38(2010), pp. 86-109.

Milgrom, Paul and John Roberts. 1992. *Economics, Organization, and Management*. Englewood Cliffs, NJ: Prentice Hall.

Newell, Samuel A., and Kathleen Spees. 2011. “Preliminary Issue Description: MISO-PJM Capacity Market Seam”. Brattle Group Report Prepared for the Midwest Independent Transmission System Operator.

Rose, Nancy L., and Paul L. Joskow. 1990. “The Diffusion of New Technologies: Evidence from the Electric Utility Industry”. *The RAND Journal of Economics* Vol. 21, No. 3 (1990), pp.354-373.

United States Department of Energy Energy Information Administration. State Energy Data System Database.

United States Department of Energy Energy Information Administration. EIA Form 861 Database.

United States Government Accountability Office, 2008. “Electricity Restructuring: FERC Could Take Additional Steps to Analyze Regional Transmission Organizations’ Benefits and Performance”. Report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate.