Divestiture Policy and Operating Efficiency in U.S. Electric Power Distribution

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Abstract:

This study examines the effects of divestiture policy on the operating efficiency of US distribution utilities. We focus on the decisive 1994-2003 period when state utility commissions required or pressured utilities to create standalone generation facilities, and thereby almost incidentally standalone distribution systems. The analytical foundation of this study is the measurement of the operating efficiency of 73 distribution units of major U.S. electric utilities in each of those ten years through the use of data envelopment analysis (DEA). Using this panel of data and controlling for other possible influences, we then evaluate the effects on measured efficiency from the divestitures that many of the utilities underwent during the study period. We find that while all divestitures as a group do not significantly affect distribution efficiency, those mandated by state public utility commissions have resulted in large and statistically significant adverse effects on efficiency.

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I. INTRODUCTION

Over the past fifteen years a vast restructuring of the electric power sectors in the U.S. and many other countries has taken place. In the U.S. one of the key components of restructuring has been the divestiture of generation assets from distribution and transmission companies. Also important have been the divestiture of control (but not ownership) of transmission assets to independent system operators and regional transmission organizations, and in some states the further divestiture of marketing/supply from the infrastructure wires business of traditional distribution companies. The divestiture of generation facilities was intended, along with entry, to help create a standalone generation sector that would compete for the business of downstream marketers and distributors of power to final customers. The shifting of control of transmission assets to independent system operators (ISOs) and regional transmission organizations (RTOs) was designed to prevent discriminatory use of the grid and also to facilitate more efficient operation of the transmission grid. The purpose of separating marketing from wires was to spur entry of and competition among the marketers, leaving only the wires business for continued regulation as a natural monopoly.

The common thread running through these and other reforms in the electricity sector has been the effort to inject competition wherever possible, with the expectation that stronger competition would result in lower overall costs of producing and delivering power and ultimately lower prices to consumers. Evidence has now begun to address whether these expectations have been met. At the sectoral level, a few studies find evidence of improvements in the operating efficiency of the post-divestiture generation sector. Notably, studies by Bushnell and Wolfram (2005) and by Fabrizio et al (2007) report an increase in several measures of fuel and/or non-fuel efficiency of power plants after divestiture.

These latter studies are important in that they suggest the very real possibility of efficiency improvements from divestiture in the generation sector. But divestiture actually created two standalone industries–distribution as well as generation[1]. There appears to have been no commonly held or understood hypotheses concerning the effects of restructuring on distribution, nor have there been any studies of the effects of divestiture policy on the distribution sector. This omission is notable for two reasons. First, the distribution sector represents fully 35 percent of the value added in the industry, so any effect of divestiture on distribution is likely to be quantitatively significant. Second, the overall assessment of divestiture policy must consider its effects not only on generation, but also on the simultaneously created standalone distribution sector. Indeed, a sufficient decline in distribution efficiency might even outweigh gains to generation and result in an adverse judgment about divestiture policy overall.

This study examines the effects of divestiture policy on the operating efficiency of distribution utilities. We focus on the decisive 1994-2003 period when state utility commissions required or pressured utilities to create standalone generation facilities, and thereby almost incidentally standalone distribution systems. We examine major divestitures both in general and also with particular respect to those that were forced upon utilities by state public utility commissions or legislative action. The possibility of an adverse effect from divestiture policy is

[1] Attempts by FERC to create a separate transmission sector, made up of Regional Transmission Organizations (RTOs) have been only partly successful.

most obvious in these latter cases which were least likely to correspond to utilities' perceived self-interest.

The analytical foundation of this study is the measurement of the operating efficiency of 73 distribution units of major U.S. electric utilities in each of those ten years through the use of data envelopment analysis (DEA). DEA generates a numerical score for each distribution utility in each year, a score that represents its efficiency of input use relative to best practice in that year. Using this panel of data and controlling for other possible influences, we then evaluate the effects on measured efficiency from the divestitures that many of the utilities underwent during the study period. We find that while all divestitures as a group do not significantly affect distribution efficiency, those mandated by state public utility commissions have resulted in large and statistically significant adverse effects on efficiency.

This paper is organized as follows. The next section provides some further background on these industry changes and on the literature that has previously examined them. Section III discusses the data and modeling.. Results and implications are set out in Section IV, while Section V concludes.

II. BACKGROUND TO THE INDUSTRY AND ISSUES

Divestitures in the electricity sector were the logical outgrowth of the Energy Policy Act of 1992, which sought to promote wholesale market competition through a policy of open access to transmission lines owned by large vertically integrated utilities. Those utilities often impeded transactions between buyers and independent or outside sellers who needed transmission services. In response, the Federal Energy Regulatory Commission in 1996 issued an order requiring socalled "functional separation" of integrated utilities' operations, with separate administrative units for generation and transmission, and with separately priced transmission services.

Functional separation was intended to achieve the objective of open access in the least intrusive manner, but in practice it failed to prevent vertically integrated utilities from exploiting their ownership and control of the transmission grid. This prompted a further FERC order in 1999 that sought to remove control of transmission from vertically integrated utilities by transferring grid operating decisions to ISOs and RTOs. These latter institutions were charged with running the transmission grid on a nondiscriminatory basis, as well as performing a number of other tasks normally associated with traditional integrated utilities. Exactly how well ISOs and RTOs have executed these tasks, and at what costs, are important, and controversial, issues.

Simultaneous with and supportive of these reforms, many states sought to have the traditional utilities within their jurisdictions divest their generation plant and thus become pure or nearly-pure distribution utilities. Such divestiture, it was believed, would help create broader and deeper markets for wholesale power. Divestiture occurred in a variety of different manners. In states such as New Hampshire and Connecticut, state laws or orders of the public utility commissions simply mandated divestiture. An alternative scenario involved utilities being coaxed into divestitures in trade for regulatory approval of other measures they sought, for example, permission to merge, recovery of stranded costs, or adoption of incentive regulation to replace cost of service. For example, AEP's proposal to acquire Central and SouthWest Corp. was approved only on the condition that the parties divest more than 1000 MW of generation capacity in Texas. Finally, in some states such as Pennsylvania, New Jersey, and Maryland, utilities undertook divestiture apparently by themselves. Whether this was truly voluntary is open to debate, since little happened during these years that was not conditioned by actual or prospective regulatory action.

The resulting shift of generation assets was truly massive. Between 1992 and 2000, some 300 plants constituting 22 percent of all generation capacity in the U.S. had been sold or transferred to non-utility subsidiaries of investor-owned utilities (EIA, 2000). That percentage had been expected to double in the following decade, although subsequent problems in California and other markets that had undergone restructuring fueled doubts about further reforms. Mirroring the emergence of standalone generation, of course, has been the creation of a substantial number of new distribution utilities. While pure distribution utilities had previously existed, the vast majority of those were publicly owned utilities or rural electric coops. The new distribution utilities are investor-owned and profit-oriented. They usually are in name, personnel, and operations continuations of the vertically integrated utilities from which they sprang.

It should be noted, however, that a significant number of investor-owned utilities remained vertically integrated to some considerable degree throughout this period of active restructuring. This was due to the fact that some operated in regions less committed to a policy of deintegration, while others simply resisted state and federal pressures. Those utilities' experiences provide a benchmark for evaluating the performance of those utilities undergoing divestiture.

Our focus will be on the effects of major divestitures on the efficiency of standalone distribution utilities. The reasons that divestiture might affect distribution efficiency follow from the arguments concerning vertical integration, of which divestiture is a uniquely large and involuntary example.[2] In principle, vertically integrated utilities might benefit from economies of at least three classic sorts.[3] First, there may be interdependencies between stages of production in the form of coordination of scheduled shutdowns, joint optimization of generation and transmission investment, and better information flows between stages for real-time operation, among others. Second, these advantages may be reinforced by transactional economies resulting from contractual incompleteness, asset specificity, and opportunistic behavior. Third, vertically integrated firms may avoid double marginalization, as firms with pricing discretion at each stage engage in successive mark-ups (although this effect may be attenuated by regulation).

On the other hand, deintegration and divestiture may also have some efficiency benefits. After shedding generation plant, deintegrated utilities remain only in the distribution business. Since this becomes their only source of income, they may focus more intensively on it and perform more efficiently than before. In addition, to the extent that certain aspects of their distribution business may be subject to some retail competition, competitive forces may drive them to achieve greater efficiency after divestiture. And finally, it is possible that vertical integration is simply a neutral factor, creating neither benefits or costs.

These conflicting tendencies of vertical integration have been subject to empirical test in electricity. Studies by Henderson (1985) and Hayashi (1997), for example, estimate cost

[2] A search for literature on the effects of divestitures in general produced surprisingly little, most of which involved the rather special case of the AT&T divestiture. See, for example, Chen and Melville (1986) and Cho and Cohen (1997). Much of the rest of what exists can be found in Ravenscraft and Scherer (1987).

[3] For a standard discussion of such vertical economies, see Church and Ware (2000), ch. 22.

functions that permit testing for the mathematical separability of generation from the transmission and distribution stages. Both reject separability, indicating likely vertical economies. Closely related to this are studies by Gilsdorf (1994) and by Lee (1995) examining cost complementarity between generation, transmission, and distribution. These reject cost complementarity, although that condition is sufficient but not necessary for economies of scope or vertical economies. Tests for overall vertical economies strengthen these findings. Kaserman and Mayo (1991) and Kwoka (2002) estimate multi-stage cost functions which allow for direct tests of overall vertical economies, finding significant economies between the generation and transmission/distribution stages for all but the smallest utilities.[4]

In a study with some similarities to our own, Delmas and Tokat (2005) report that a greater degree of integration by electric utilities is associated with higher efficiency, as measured by data envelopment analysis, whereas a separate variable for divestiture is associated with lower efficiency. Both variables, however, are defined in ways that obscure interpretation.[5] Mansur's

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[4] Two recent international studies deserve note as well. Nemoto and Goto (2004) test the technological externality effects of generation assets on the costs of transmission and distribution stages in their study of vertically integrated Japanese utilities. Their results show that downstream costs depend on the generation capital, suggesting significant economies of vertical integration. Fraquelli et al (2005) analysis of Italian municipal electric utilities finds significant vertical economies for average-size and large utilities while failing to find any significant effects for smaller than average-size utilities. Efficiencies associated with vertical integration are largest for fully integrated utilities, confirming results found in most other studies. See also the survey by Michaels (2006).

[5] They find that a high degree of integration is associated with greatest efficiency, but they also report a U-shaped relationship through the range of vertical integration. The latter seems likely an artifact of their use of a demeaned measure of vertical integration, together with positive coefficients on both the linear and quadratic terms for the degree of integration. Also problematic is their measure of divestiture, which is defined as 0 if there is no deregulation of any kind, 1 if

study (2007) of PJM utilities concludes that vertical integration results in greater control of upstream market power, while divestiture permits generators in some markets to lower output and extract excess profit. Similar concerns over market power in a deintegrated setting underlies findings in Bushnell et al (2008)

These results concerning vertical economies provide a context in which to view previously-noted studies suggesting efficiency benefits from divestiture on the generation stage. Bushnell and

Wolfram (2005) report improvements in fuel efficiency of about two percent for those generating units that underwent divestiture to non-utility ownership. Notably, however, gains of essentially the same magnitude also resulted from incentive regulation of non-divested units, leading the authors to conclude that incentives rather than ownership changes were responsible for performance improvements. The Fabrizio et al study (2007) finds that labor and non-fuel expenses–but not fuel expenses--for generating plants in restructuring markets fell by about three to five percent. Interestingly, this improvement took place before divestiture, a fact which they interpret as indicating anticipatory action by the utility.

While this evidence is not entirely unambiguous, it does suggest that divestiture may well improve generator efficiency but that overall diseconomies attend vertical deintegration. Together these findings imply that offsetting losses must arise elsewhere in the vertical chain.

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there is deregulation, and 2 if there is deregulation plus divestiture. This scaling does not distinguish the effect of simple deregulation but without divestiture (the change in value from 0 to 1) from that divestiture (the change from 2 to 1–or perhaps from 2 to 0). Moreover, these are state-level variables and may therefore not capture the status of all utilities in the jurisdiction.

The present study can be viewed as an effort to determine whether such diseconomies manifest themselves at the distribution stage and, if so, whether they might outweigh any gains within generation. These questions in turn serve as the foundation for evaluating divestiture policy in the electricity sector.

III. DATA, METHODOLOGY, AND MODEL

This section begins with a discussion of the data used in this study. It then describes the two-step process of analysis, first using data envelopment analysis to measure efficiency, and then regression analysis to test for causal relationships affecting efficiency. We take these up in turn.

A. DATA

The data base used in this study consists of 73 distribution utilities, all subsidiaries of the major U.S. investor owned utilities for the period 1994-2003. We have some information on a total of 305 such utilities, but several considerations reduce the number of usable observations. Some are generators, which are not the focus of this study and hence are excluded. Also excluded are a number of observations involving non-responses or unresolvable data inconsistencies, typically involving relatively small utilities. Finally, we seek a balanced panel and thus do not use observations that do not represent a continuous series. Nonetheless, the utilities that are included in our data base account for well over half of total MWH of distribution in each year (for example, 57% for the typical year 2000).

For each such utility we have comprehensive data on its finances and operations derived from FERC Form 1 filings,[6] together with supplementary information extracted from Electrical World Directory of Electric Utilities. These include total sales, residential sales, total customers, residential customers, distribution line length, total distribution costs, total administrative costs, and customer service costs. Definitions of variables used at each stage are discussed below. These data have distinctive strengths. Since distribution has been relatively unchanged in function, and since these utilities have had unchanged FERC reporting requirements, the data represent a consistent basis for measuring performance at the level of the individual operating unit before and after deintegration or divestiture. By contrast, generation now involves numerous independent suppliers that are not required to report on their operations and finances, while transmission is notoriously difficult to compare and assess. Our data avoid these problems.

One major complication is that by the end of 2003 approximately 20 states had partially deregulated their retail markets, so that customers could choose their suppliers. In those states the traditional distribution utility performed only the local transport function, rather than transport and product supply, although most served as default suppliers as well. This arrangement affects the local distribution utilities' reported customer numbers, output, and costs, which are recorded separately for bundled and unbundled services. Consistent records for each affected utility in the sample were reconstructed from data from a different utility report–namely, Form 861--with additional information as necessary from direct contacts with state utility commission staff.

For the 73 utilities in the data base, our focus is on major policy-induced divestitures.

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[6] Federal Energy Regulatory Commission Form No. 1 is a comprehensive financial and operating report submitted annually by all investor-owned utilities. We employ a version processed by Platts.

Defining a "major divestiture" and identifying the year in which it occurred are important threshold issues since the extent of generation plant owned and the degree of vertical integration vary to modest degrees in many years. These routine variations need to be distinguished from the major policy divestitures that constitute our focus. Our methodology involved detailed examination of the actual divestitures undertaken by each of the utilities in the data base. State PUC records, primarily on commission websites, constituted the primary source of information, although in a number of cases telephone contact with PUC personnel was required for clarification or confirmation. Based on this examination, we define a major divestiture as a year-to-year decline in a utility's generation plant of at least one-half its initial amount, where that initial amount had to represent a substantial fraction of its requirements.[7] In some cases divestitures occurred over a period in excess of a single year, in which case the divestiture was associated with the initial year.[8]

From this process, we establish that 28 of the 73 firms in the data base underwent a major divestiture during the sample period, while 45 of them did not. As shown in Table 1, these major divestitures resulted in a decline from 69.1 percent to 18.8 percent in the proportion of electricity requirements that these utilities self-supplied. This fraction–a measure of the extent of vertical integration–makes clear that these utilities were transformed from largely integrated to

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[7] This latter criterion is intended to exclude, for example, a utility whose generation plant declined from 5 percent of its requirements to 2 percent–a greater-than-one-half decline that nonetheless does not constitute a major divestiture. What constituted a substantial decline and therefore a major divestiture was in all cases clear from the data.

substantially deintegrated in a very few years. By contrast, the degree of deintegration by non-divesting utilities declined only modestly–from 70.0 percent to 61.3 percent--during the study period. Figure 1 shows the precipitous nature of the decline in the degree of integration for all 73 utilities, for those that divested, and for those that did not.

We are interested in comparing the efficiency of divesting utilities with that of comparable non-divesting utilities. We also distinguish the experience of utilities for which divestiture was mandated by the state public utility commission or legislative action, versus those undertaken at the utility's own discretion or at most involving a quid pro quo. This distinction was made based on analyses of the public utilities commission records and in some instances direct inquiry to the PUC. Of the 28 divesting utilities, eight involved mandatory divestitures, the remaining twenty non-mandatory. Data for utilities in these categories are also reported in Table 1.

B Data Envelopment Analysis

The analytical methodology used in this study is data envelopment analysis (Coelli et al, 1998). DEA uses observed inputs and outputs of decision making units (DMUs) or firms in the sample to construct a best practice frontier. Operation of each actual firm is then compared to a linear combination of best practice firms which can produce the same amount of output as the firm in question, but generally with lesser amount of inputs. Figure 2 illustrates relationship between firm 1's input utilization relative to best practice production of output amount X, the latter defined by DMUs labeled 2 and 3 and 4. The radial distance from the best practice frontier

[8] That is, if generation plant went from 40 to 20 percent in the first year, and then 20 to 10 percent, the year of the first reduction was taken as the major divestiture. Controls for the second year in such cases made little difference in the results.

to any non-frontier firm 1's input usage measures the technical inefficiency for firm 1. Specifically, the ratio OD/OR measures the relative efficiency for all firms outside the frontier, with a “1" denoting a best practice firm and “0" the lowest efficiency score possible (although no actual utility approached this lower bound).

Mathematically, the efficiency scores are calculated by solving linear programs[9] of the form shown in Equation (1) below. Assuming that the firm uses K inputs and M outputs, X and Y represent K H N input and M H N output matrices, respectively. The input and output column vectors for the ith firm are represented by x_i and y_i, respectively, and 8 represents an N H1 vector of constants. Then for the ith firm in a sample of N firms, the program solves for a scalar 2 that equals the efficiency score, as follows:

$$\min_{2,8} 2 \ \text{ s.t.} \qquad (1)$$

$$- y_i + Y\, 8 \geq 0$$

$$2\, x_{i,D} - X_D\, 8 \geq 0$$

$$8 \geq 0$$

This optimization is solved once for each firm to calculate the efficiency of the firm with respect to all other firms in the sample. The DEA scores calculated in this manner represent technical efficiency.[10]

Relative to other techniques for measuring efficiency, DEA has several advantages

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[9] This discussion of the linear program draws from Hattori et al (2005).

[10] Cost as well as allocative inefficiency require input prices, beyond the scope of the present inquiry.

(Jamasb and Pollitt, 2001). It is non-parametric, so that it avoids the need to choose the functional form. It handles multiple outputs quite readily, a useful capability in the present context. And it allows for a straightforward calculation of technical efficiency. Alternative techniques such as corrected ordinary least squares and stochastic frontier analysis also have their distinctive merits, but in comparing the performance of these three techniques, Jamasb and Pollitt (2003) find that results are highly correlated. We therefore take advantage of DEA, with the expectation that other techniques would show similar results.

Application of data envelopment analysis requires two additional choices–input vs. output orientation, and constant vs. variable returns to scale. We employ what is termed input oriented DEA in order to measure the efficiency of firm operation in minimizing inputs to produce a given level of output. This is more suitable to the nature of distribution utilities that meet largely exogenous demand, than would be output oriented DEA which measures the efficiency of firms in maximizing outputs from a given level of inputs. Also, we assume constant returns to scale in the belief that units undergoing divestitures or other structural changes are making precisely the kinds of decisions that ensure they remain at optimum scale. Moreover, many of these distribution utilities are subsidiaries of holding companies that help ensure realization of any scale economies not readily achieved at the unit level. Finally, the variable returns to scale assumption compares each firm to different best practice firms, tending thereby to attribute any efficiency differences to scale differences and obscuring underlying relative performance.

Our DEA model specifies three output variables–MWH sales, number of customers, and distribution network length. Each of these represents a cost-causal feature of distribution utility operations: Costs rise with output, but they also rise with the number of customers to whom that output is delivered and sold,[11] and with a greater number of distribution miles over which that output is supplied. These factors have been found to be important in previous empirical studies in the literature (e.g., Jamasb and Pollitt (2001); Kwoka (2006)). Two alternative input measures are employed–one for short-run variable costs, the other capturing longer-run cost considerations. Both use a single variable–the value of input cost--as the relevant measure, thus aggregating fuel, labor, materials, and (in the case of long run costs) capital expenses. This aggregation is appropriate so long as input tradeoffs are weak, as they surely are between fuel and labor costs, fuel and materials costs, and labor and materials costs (Jamasb and Pollitt (2003)). On this assumption, such measures have been found to be a sound basis for comparison of real resource usage.

The short-run variable cost *OPEX* measure consists of total non-capital costs of distribution, defined as the sum of distribution costs, plus customer service costs, plus a prorated share of total administration costs. The prorating factor is the ratio of wages in distribution plus service, to total wages in operations and maintenance.[12] Longer run costs should include some measure of capital costs. The most obvious measure–imputed capital costs–has a number of significant deficiencies in the present context. It is sensitive to assumptions concerning capital valuation and rate of return. In electricity, imputed costs can be so large as to dwarf operating expenses, making their sensitivity to assumptions a potentially serious flaw. And perhaps most importantly for our purposes, since distribution capital–wires, etc.--is so long-lived, it can

[11] We use the number of residential customers, which account for the vast majority of total customers.

scarcely be altered by a utility in the relevant period of time.

Accordingly, we take as a measure of long-run costs the sum of operating costs plus the utility's *current* capital expenditures. The use of current capital expenditures has two advantages as a measure of relevant costs: It is indisputably a controllable expenditure in the relevant time frame, and it is clearly related to the capital investment program of the utility. Of course, current capital decisions are influenced by factors other than efficiency, including such things as market conditions, investment opportunities, and strategic decisions. For all these reasons, the results on total controllable costs *TCEX*, while illuminating, should be interpreted with caution.

C. Regression Model

The second step involves the regression analysis of the computed DEA scores for 1994-2003, to test for the impact on distribution utilities of major divestitures of their generation plant. Our dependent variable is the DEA-based efficiency score ranging from 0 to 1. The independent variables of interest include a variable for the post-divestiture years for those utilities that underwent major divestiture during this period. These results compare divesting utilities' post-divestiture experience to the control group that underwent no major divestitures. Alternative specifications of two kinds follow. The first includes two variables for divesting utilities, one for those that underwent mandated divestitures and a second for divestitures that were not mandated. The former are less likely to represent utilities' own preferences and perceived self-interests and thus more likely to sacrifice efficiency of performance. The second variation introduces a set of post-divestiture year dummies, instead of a single post-divestiture variable, in order to test for

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[12] For a similar approach, see Jamasb and Pollitt (2003).

time-dependent effects from divestiture. Other models examine separate subsets of the data for each type of divestiture. Finally, the regression controls for the ratio of residential sales to total sales, denoted *RES-PCT,* since the provision of residential sales is particularly costly due to additional infrastructure and service requirements. We shall discuss the definitions of these variables as they arise in particular regression models.

The structure of our data and our model raise some issues of the appropriate estimation technique. We note in particular that DEA scores are censored at 1, a characteristic that might suggest use of tobit analysis. In the present case, however, this censoring is not a constraint on the observed outcomes of a behavioral relationship that might logically produce values in excess of 1, for example, excess demand for a good or service which is not observed due to fixed supply. Rather, the upper bound of 1 is the result of the fact that DEA scores are definitionally bounded at 0 and 1. Since this is not the data generating process that underlies tobit, that technique is neither necessary nor appropriate. Moreover, none of the observations involving the divesting firms that are our primary focus involve values of 1.

Accordingly, the regression analysis proceeds using GLS estimation with fixed effects. Fixed effects control for any unobserved differences among the utilities, thus helping to ensure that the reported results are not simply reflecting such other characteristics. Results using random effects, arguably useful given the fact that our sample does not include many utilities,[13] are not substantially different and are available upon request.

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[13] For discussion, see Greene 1993), pp 469-471.

IV. RESULTS AND DISCUSSION

We begin by examining the effects of major divestitures of generation on short-run operating efficiency of distribution utilities, and then turn to longer run efficiency as measured by controllable costs. In each case we examine alternative specifications and subsets of the data in order to determine the importance of the type of divestiture and the time path of effects.

A. Operating Efficiency and Divestiture Type and Timing

The initial cut into the data is simply a regression of DEA scores of operating efficiency *OPEX* on two variables–the dummy variable *POST-DIVEST* that takes on a value of one for each post-divestiture year for the 28 utilities that experienced a major divestiture, and a variable for the percent residential sales of the utility (*RES-PCT*). The results of estimating this model are given in Table 2, Column (a). With respect to *RES-PCT*, we note that here and in most results, this variable behaves predictably: DEA-measured efficiency is lower for utilities whose customer base is more heavily residential. Hence, we will not discuss this variable further.[14] In this most general form, the coefficient on *POST-DIVEST* is negative but lacks statistical significance (t= .67). This result obviously does not suggest an important effect of divestiture, although the next two specifications reveal more of the actual effects. .

The specification in column (b) replaces the variable *POST-DIVEST* for all divesting utilities with two variables. *POST-MAND* is a dummy variable that takes on a value of one for the post-divestiture years of those eight utilities whose divestiture was mandated, while the dummy variable *POST-NON* is the analogous dummy variable for the twenty utilities that divested but not under a mandate to do so. A clear difference now emerges in the post-divestiture efficiency experience of these types of divestiture. Mandated divestitures are associated with a .029 point drop in efficiency relative to the base group of non-divesting utilities, whereas non-mandated divestitures had essentially no effect on measured efficiency scores. Despite the uncertain statistical significance of *POST-MAND*, this does indicate some negative effect from divestiture policy for the subset of utilities that had divestiture forced upon them by state action. The estimated effect of -.029 points represents about four percent of the overall average DEA efficiency in the data base of .69. In contrast, divestitures that were strictly voluntary or involved some quid pro quo exhibit no real difference from the control group of non-divesting utilities. The coefficient on *POST-NON* is .001 with a t-statistic of .09.

A further variation on the initial specification takes into account the fact that divestiture policy, like many others, is unlikely to have its full effect immediately. Accordingly, we define a series of timing dummies *POST1*, *POST2*, ...*POST6* for successive years after the particular utility's major divestiture. *POST1* equals one for the first year after divestiture, *POST2* for the second year, and so forth. These variables effectively disaggregate the single variable *POST-DIVEST* in the earlier model. Column (c) reports the results of this estimation.

While none of the estimated coefficients achieves statistical significance, the results suggest that timing may well matter. Initially efficiency appears essentially unchanged, as indicated by the small and insignificant coefficient on *POST1*. This is probably due to the fact that the very first year is a transition period in which both operations and accounting reflect the

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[14] Elimination of this control variable does not affect the results in any substantial way.

utility's immediate past history. Beginning with the second post-divestiture year, however, suggestions of possible effects of divestiture emerge. Measured efficiency in that second year is .015 lower than prior to divestiture, with subsequent years .022, .005, and .027 lower. The year-six results indicate an efficiency improvement, but this result is based on exactly two data points where POST6 equals one. Since this is likely a small numbers quirk rather than a meaningful substantive phenomenon, we do not focus on this result here or in later results.

The results in column (b) and those in column (c) reinforce the conviction that divestiture type and timing matter. This becomes yet more apparent in the results in Table 3, which splits the sample into utilities that divested under a mandate, versus those that divested but not as a result of a mandate.[15] Their efficiency performance is now starkly and significantly different. Column (a) re-estimates the model in the last column of the preceding table, which utilized the dummy variables *POST1*, ...*POST6* to capture the time path of divestiture effects on efficiency. For these utilities that divested under mandate, after the transition year *POST1*, their measured efficiency declines precipitously–by .160 points in year 2, followed by .125 points, .243 points, and .244 points. All of these estimates are statistically significant, with t-values no less that 2.80. Quite clearly, mandated divestitures have adversely affected utilities' operating efficiency.

Column (b) respecifies the previous model in a manner intended to summarize the post-divestiture experience of utilities undergoing mandatory divestiture. Specifically, we define POST26 as a dummy variable taking on a value of 1 for the second through sixth post-divestiture

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Nor does the inclusion of other possible controls.

year.[16] Together with *POST1* (held separate based on past results), this model is estimated and the results reported in column (b). As before, *POST1* is insignificant both in magnitude and statistical reliability. *POST26*, however, is highly significant, and its magnitude implies that across all post-divestiture years starting with year 2, measured efficiency of distribution utilities falls by .148 points, or about twenty percent, as a result of mandatory divestitures.

As might be expected from previous results, the post-divestiture efficiency experience of non-mandated divestitures is quite different. Column (c) of Table 3 reports the results of estimating a model analogous to that in column (a) for mandatory divestitures, but in contrast to those results, the estimated coefficients on *POST1, ...POST5*[17] are all small, positive-valued, and statistically insignificant. It seems clear that where utilities choose to divest or are willing to do so as part of a larger bargain with the regulatory agency, their efficiency experience was quite different–not necessarily positive, but certainly avoiding the sharp declines experienced by mandated divestitures.

For symmetry with the column (b) specification, column (d) aggregates all the post-divestiture effects (including in this case that in the first year) into the single variable *POST15.* Given column (c) results, it is not surprising that the estimated coefficient on *POST15* is small,

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[15] Splitting the sample examines the effects of divestiture on each sample separately, given that such divestiture has occurred to those utilities. This avoids possibly biased estimates from any endogeneity.

[16] Since POST6 is based on exactly two observations, it should not be interpreted as truly indicative of a sixth year effect. We nonetheless include it in *POST26.*

[17] The only two observations on *POST6* are for mandated divestitures, so that variable drops out of this regression on non-mandatory divestitures.

positive, and statistically insignificant. The operating efficiency of utilities undergoing non-mandatory divestitures is essentially unchanged by that divestiture. Their efficiency is little different after divestiture versus before–but quite different from that of utilities undergoing mandated divestiture.

Overall, we conclude that divestiture has a substantial adverse effect on the operating efficiency of utilities that were required to divest their generation assets. This adverse effect does not arise in the case of non-mandatory divestitures. We next turn to the issue of the effects of these same divestitures on total controllable costs.

B. TOTAL CONTROLLABLE COSTS AND DIVESTITURE TYPE AND TIMING

As discussed previously, total controllable costs are a broader measure of utility efficiency than operating expenses insofar as they include current capital expenditures to represent discretionary capital costs. Data envelopment analysis of total controllable costs *TCEX* generates a set of efficiency scores for all 73 utilities for the years 1994-2003, much as for *OPEX*. This section reports the results of regression analyses of those scores.

Regression analysis of *TCEX* scores utilizes the same model specifications and estimation method as in the case of *OPEX*. The results largely track the findings of the earlier analysis, as well. Table 4 examines the full sample of utilities, while Table 5 splits the sample into utilities that underwent mandatory divestitures vs. those with non-mandatory divestitures. Column (a) of Table 4 estimates the sparest model, with just *POST-DIVEST* and the control variable *PCT-RES* as explanatory variables. There is no indication from the estimated coefficient on *POST-DIVEST* that divestitures overall altered the efficiency of utilities, as measured by TCEX.

That conclusion is subject to revision based on column (b) results. This specification finds significantly lower efficiency scores for utilities undergoing mandatory divestitures (*POST-MAND*) but no significant effect–albeit a slightly positive coefficient--for those which undertook divestiture largely at their own initiative (*POST-NON*). As with *OPEX*, it seems clear that mandated divestitures represent structural changes that are not in the interests of the affected distribution utilities. The final set of results in this table, in column (c), reports on the efficiency effects of divestitures on a year-by-year basis. The results are broadly similar, though weaker, than those found for *OPEX*. *POST1*, the variable for the first post-divestiture year, has a positive but insignificant coefficient, followed by a series of year dummies with negative coefficients. Only one of the latter approaches statistical significance, so as with *OPEX*, there is only modest indication of time-dependent effects for divesting utilities.

Table 5 disaggregates those utilities into those for which divestiture was mandated vs. those that divested largely at their own discretion. The model in column (a) estimates the year-by-year model for mandatory divestitures. Apart from the first year after divestiture, which again has a weakly positive coefficient, efficiency is lower in all years from the second through the sixth after divestiture. Four of those five estimated yearly effects are significant or nearly so, with magnitudes in the range of .119 through .182. As with *OPEX*, mandated divestitures have adverse effects on distribution utilities. This result is corroborated in column (b), which combines *POST2* through *POST6* into a single summary variable for those years. *POST26* emerges with a negative and statistically significant coefficient of .109, leaving little doubt about the reduction in efficiency following such divestitures.

Non-mandated divestitures are examined in columns (c) and (d) of Table 5. Since there is little evidence of effect–either positive or negative–from such divestitures in the preceding table, or for that matter with respect to *OPEX*, a reasonable expectation here would again be for little if any effect. Indeed, that is the case. Column (c) indicates a negative but generally small and insignificant effect of non-mandatory divestitures on a year-by-year basis. Only one year dummy out of five–specifically, *POST3*--carries a t-value in excess of one. Column (d) reports the results of combining these five year dummies into a single post-divestiture variable *POST15*. While the coefficient is negative, its t-value is only .73, leading again to the conclusion that non-mandated divestitures do not have a clear effect on utility performance.

In summary, we conclude that with respect to our measure of overall costs, the results are quite similar to those for operating costs only. Specifically, divestitures that were mandated by state regulatory authorities after the first year reduce utility efficiency by a substantial amount and for a significant period of time. In contrast, divestitures undertaken largely at the utilities' own initiative are not associated with such adverse effects.

V. SUMMARY AND CONCLUSIONS

The large number of divestitures in a relatively short period of time is nearly unprecedented in any single industry. In the U.S. electricity sector, these divestitures were largely the result of public policy that sought to foster competition among independent generators. Considerably less attention was paid to the possible effects of this policy on the simultaneously created standalone distribution utilities. This study represents the first evaluation of the latter sector in light of divestiture policy.

We have found that divestitures mandated by state regulatory authorities had adverse effects on efficiency, measured both by operating costs and also by total costs including capital expenditures. These effects have been both large and significant, casting considerable doubt on the policy of forced divestiture. Notably, however, utilities that undertook divestitures that were not the result of mandate did not experience any adverse effects on their efficiency.

These results raise questions about the merits of a centerpiece of electricity restructuring namely, mandated divestitures in order to create standalone generation sector. The resulting standalone distribution utilities appear to suffer from significant and persistent reduced efficiency. Taken by itself, this represents a cost of divestiture policy, but it also raises a question about the overall benefits of the policy. Whatever the benefits at the generation stage, these must be weighed against the costs to distribution utilities in order to arrive at a comprehensive judgment about divestiture policy as a whole. That judgment is not rendered here, but is certainly a subject that needs to be on the policy agenda.

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TABLE 1
All Utilities in the Sample

Category	Number	Mean Total Sales (M MWh)	Degree of Vertical Integration 1994	Degree of Vertical Integration 2003
All	73	22,200	0.696	0.450
Non-Divesting	45	19,900	0.700	0.613
Divesting	28	25,900	0.691	0.188
Mandatory	8	17,200	0.621	0.288
Non-mandatory	20	29,300	0.719	0.148

TABLE 2
Regression Analysis on OPEX: Full Sample

	(a)	(b)	(c)
POST-DIVEST	-.008		
	(.67)		
POST-MAND		-.029	
		(1.45)	
POST-NON		.001	
		(.09)	
POST1			.001
			(.08)
POST2			-.015
			(.82)
POST3			-.022
			(1.05)
POST4			-.005
			(.22)
POST5			-.027
			(.85)
POST6			.150
			(2.47)
RES-PCT	-.198	-.209	-.187
	(2.56)	(2.69)	(2.37)
CONSTANT	.740	.743	.737
	(32.0)	(32.0)	(31.2)
R^2	.031	.030	.037
F	8.15	7.63	6.20
N	730	730	730

TABLE 3
Regression Analysis on OPEX: Split Samples

	Mandatory		Non-Mandatory	
	(a)	(b)	(c)	(d)
POST1	.014	.016	.017	
	(.44)	(.53)	(.66)	
POST2	-.160		.026	
	(4.93)		(.89)	
POST3	-.125		.051	
	(2.80)		(1.51)	
POST4	-.243		.067	
	(5.38)		(1.66)	
POST5	-.244		.086	
	(3.79)		(1.63	
POST6	-.206			
	(3.07)			
POST26		-.148		
		(4.92)		
POST15				.023
				(1.01)
RES-PCT	-.698	-.553	.236	.153
	(3.68)	(2.98)	(1.51)	(1.03)
CONSTANT	.829	.792	.581	.603
	(15.9)	(15.3)	(12.8)	(13.9)
R^2	.080	.347	.050	.059
F	7.98	8.50	1.92	2.38
N	80	80	200	200

TABLE 4
Regression Analysis on TCEX: Full Sample

	(a)	(b)	(c)
POST-DIVEST	-.003		
	(.22)		
POST-MAND		-.055	
		(2.16)	
POST-NON		.020	
		(1.10)	
POST1			.018
			(.84)
POST2			-.004
			(.18)
POST3			-.042
			(1.57)
POST4			-.004
			(.13)
POST5			-.036
			(.88)
POST6			.100
			(1.30)
RES-PCT	-.150	-.178	-.162
	(1.53)	(1.82)	(1.61)
CONSTANT	.784	.792	.787
	(26.8)	(27.0)	(26.3)
R^2	.084	.079	.092
F	12.2	11.8	8.83
N	730	730	730

TABLE 5
Regression Analysis on TCEX: Split Samples

	Mandatory (a)	(b)	Non-Mandatory (c)	(d)
POST1	.055	.023	-.015	
	(1.32)	(.62)	(.42)	
POST2	-.146		-.017	
	(3.52)		(.41)	
POST3	-.014		-.078	
	(.25)		(1.59)	
POST4	-.182		-.033	
	(3.16)		(.57)	
POST5	-.130		-.063	
	(1.58)		(.82)	
POST6	-.119			
	(1.40)			
POST26		-.109		
		(2.89)		
POST15				-.024
				(.73)
PCT REG	-.807	-.754	.220	.276
	(3.33)	(3.25)	(.97)	(1.29)
CONSTANT	1.01	.992	.653	.638
	(15.1)	(15.3)	(9.94)	(10.2)
R^2	.429	.400	.064	.071
F	6.63	7.40	2.50	3.22
N	80	80	200	200

FIGURE 1

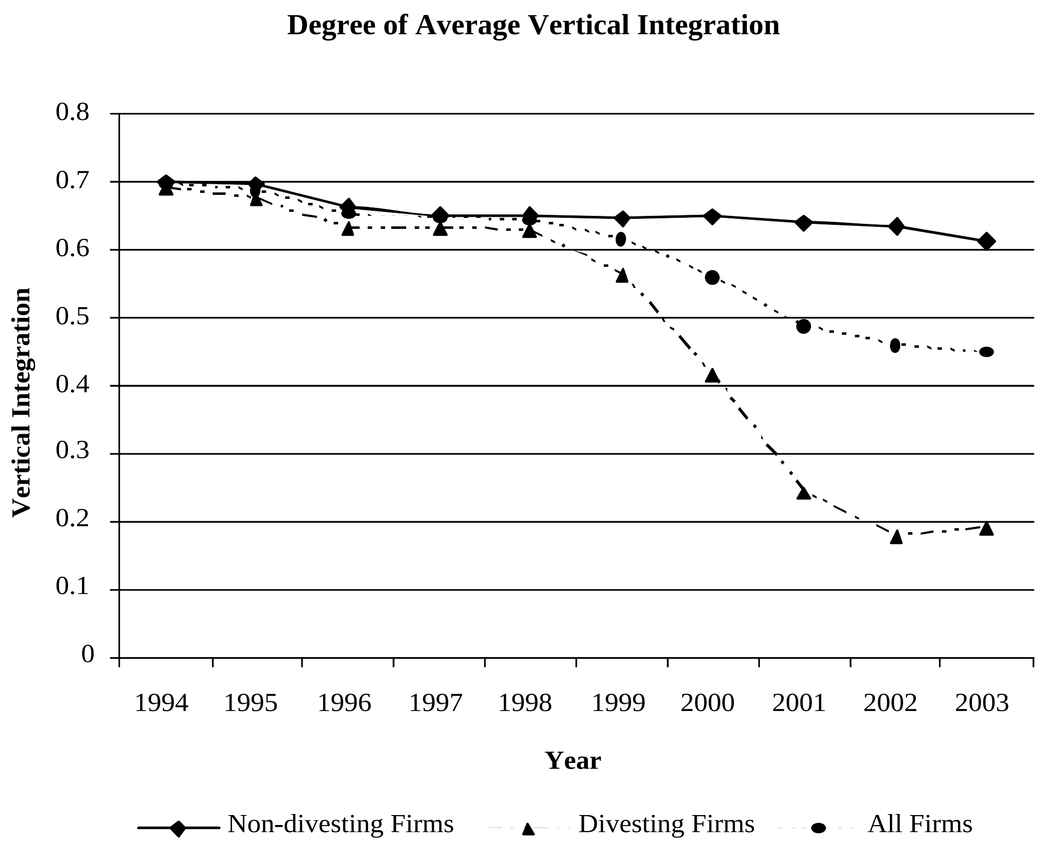
Degree of Average Vertical Integration
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Vertical Integration
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Year
Non-divesting Firms
Divesting Firms
All Firms

FIGURE 2

Input Oriented DEA