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Ownership Change, Incentives and Plant Efficiency: The Divestiture of U.S. Electric Generation Plants

James B. Bushnell and Catherine Wolfram*

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Abstract

Electric industry restructuring in the US has led to rapid and substantial changes in the ownership of the existing stock of electricity generating plants. Between 1998 and 2001, over 300 electric generating plants in the US, accounting for nearly twenty percent of the total generating capacity, changed hands. Moreover, because the new owners are unregulated, they face different incentives from the utilities that were operating plants under cost-of-service regulation and had weak incentives to control operating costs. We use data from several sources, most importantly information on fuel efficiency from the Environmental Protection Agency's Continuous Emissions Monitoring System (CEMS), to investigate changes in operating efficiency at plants that have been divested from utility to non-utility ownership. We examine efficiency changes relative to a set of plants that were retained under utility ownership. Our results suggest that fuel efficiency improved by about 2% following divestitures, although non-divested plants that were subject to incentive regulation also saw fuel efficiency improvements of similar magnitudes. Our results suggest that changes in incentives were the main driver behind the efficiency improvements and that the ownership transfers had little positive and possibly negative impacts on fuel efficiency.

JEL Classification: L33, L51, and L94

Keywords: Productivity, Regulation, Privatization, and Electricity Markets

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1 Introduction

Market liberalization - in the form of privatization, deregulation, or both - has been one of the dominant worldwide economic trends of the last 20 years. Initiatives to liberalize markets take their legitimacy from the belief that liberalization improves efficiency. By contrast, public ownership and economic regulation have been criticized as unnecessary obstructions to innovation and market efficiencies in many industries. In many countries, the electric utility industry is one of the most recent sectors to be transformed by these trends. Like many utility industries, electricity had been frequently characterized as a natural monopoly. This provided the justification for the formation of vertically integrated franchise monopolies to provide electric service, either as regulated investor-owned or as state-owned utilities. Innovations in both technology and economic thought have created the impetus to dismantle these franchises and deregulate the generation sector of the industry.

In the United States, liberalization initiatives swept through much of the northeast and far west between 1998 and 2002. This momentum for deregulation has now largely come to a standstill. Much of this is due to concerns created by the Calfornia crisis as well as to major increases in the price of natural gas, which had been the primary fuel used by non-utility generation companies. This provides a natural time to assess the results of liberalization to date. The bulk of economic research into the outcomes of deregulation has focused on competition issues.[1] However, an even more fundamental issue is the extent to which liberalization of electricity markets has brought about improvements in efficiency. In the absence of such improvements, the intellectual arguments in favor of liberalization are greatly diminished.

Liberalization may affect efficiency along many dimensions. Ishii and Yan (2003) examine the investment choices of deregulated firms under differing U.S. regulatory and liberalization settings. Several papers study trading efficiency in restructured markets by focusing on the pricing relationship between geographically or temporally neighboring markets.[2] In this paper,

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[1] Work in this area includes, but is not limited to Wolfram (1999), Borenstein, et al. (2002), Joskow and Kahn (2000), Puller (2003), Mansur (2003), and Bushnell, et al. (2004).

[2] Borenstein, et al. (2004), Saravia (2003), and Kleit and Reitzes (2004).

we examine the operational efficiency of power plants that have been divested from regulated utilities to non-utility generation companies. Divestiture was a centerpiece of liberalization in states that undertook a restructuring process. Over a four year period from 1998 to 2002, around 20% of U.S. generation facilities were divested. We focus on the effects of the divestitures on power plants' fuel efficiency. Fuel expenses account for about 75% of operating expenses at power plants. We utilize a panel of detailed plant micro-data to evaluate the changes in fuel efficiency at divested plants relative to a control group of plants that did not change ownership.

The efficiency of power plant operations is central to the efficiency of the industry, where generation costs comprise the majority of overall costs and an even larger portion of operating costs. However, there is some question as to the impact of restructuring on plant operations. Joskow (2003) points out that productivity in the U.S. electricity industry was amongst the best in the world under regulation. It has been argued that the major potential gains from restructuring come from promoting more rational investment choices, rather than improvements in the operations of existing generation.[3] Furthermore, irregular operating patterns motivated by attempts to exercise market power and the disruption of an ownership change could diminish operating efficiency at least in the short-run. On the other hand, there is no question that cost-of-service regulation muted the incentives of utilities to reduce costs. This is particularly true of fuel costs, which were often automatically passed on to customers. Markiewicz Fabrizio, Rose, and Wolfram (2004) find that employment and non-fuel operating expenses significantly declined at power plants owned by regulated utilities in states that undertook liberalization, indicating there was room for improvement. They did not find a similar improvement in fuel efficiency, but they did not examine operations at plants that were divested from state regulated utilities and they analyzed more aggregated data than we use in this paper.

The divestitures of U.S. power plants encapsulate two important aspects of market liberalization: ownership change and a strengthening of incentives. Beyond the divestitures, a number of U.S. plants faced higher-powered incentives without an ownership change. So, while a large num-

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[3] See for example, Borenstein and Bushnell (2000).

ber of plants changed hands, and even more were transfered to unregulated affiliate companies, still other plants remained under utility ownership but experienced changes in their regulatory regime. We take advantage of this diversity to separately identify the effects of incentive and ownership changes.

In this way, our work ties in with two strands of the general literature on firm productivity. One deals with plant ownership changes and has largely focused on corporate mergers. The dominant conclusion of this literature is that productivity improves as the result of ownership change, but that this is due to the selection of under-performing plants by the purchasing firms.[4] The other strand has examined the impact of privatization in many industries, including electricity. Villalonga (2000) provides an extensive survey of this literature and argues that political and organizational effects must be differentiated from the incentive effects of privatization. Saal and Parker (2001), Ng and Seabright (2001), and Newbery and Pollitt (1997) all find efficiency gains from privatization in the water, airline, and electricity industries respectively.

We find that fuel efficiency at divested plants did improve by roughly 2% relative to their non-divested counterparts. This gain is attributable to improvements in efficiency at the highest output levels of plants. However, most of this gain is matched by non-divested plants in states that adopted a strong form of incentive regulation. This suggests that the bulk of the efficiency improvement can be attributed to incentive rather than ownership changes. In section 2 we describe the process of liberalization and divestiture in the U.S. electricity industry. In section 3 we outline our empirical strategy and in section 4 we present our results. We conclude in section 5.

2 U.S. Electricity Restructuring

In the United States, electricity market liberalization has focused on the deregulation of private firms, as opposed to the privatization of government-owned assets. For the bulk of the 20th century, the electricity industry in the U.S. was notable for its large number of firms and the

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[4] See, for example, McGuiken and Nguyen (1995).

high degree of fragmentation of utility service territories (see Joskow, 1997). There was also a diversity of organizational forms, with investor-owned utilities, federally operated generation, municipally-owned utilities, and private non-utility generation all comprising non-trivial shares of the asset mix. Most regulation took place at the state level, with a wide variety of policies and results across the 50 states. All of this stands in contrast to the much more internally uniform approaches to ownership and regulation that were found throughout the rest of the world.

Electricity regulation in the U.S. almost always took the form of cost-of-service regulation, where utilities were guaranteed the recovery of prudently incurred operating expenses and a regulated rate-of-return on capital investments. Within the general framework of cost-of-service regulation, there was substational variation in the specfic regulatory approaches of different states. Although in theory a guarantee of cost recovery would greatly weaken incentives for cost control, the specific implementation of regulation played an important role.[5] For example, many states adopted automatic fuel-adjustment clauses in which utility rates would automatically periodically adjust in response to changes in utility fuel costs. On the other end of the spectrum, the initiation of rate hearings in other states was at the behest of the utility itself. Under such circumstances, utility cost savings would not impact revenues for a considerable time and utilities would have stronger incentives to mitigate costs. States also differed in the form and degree of their commitments to independent power production, alternative generation sources, and demand-side management programs.

During the 1990's large discrepancies in electric rates between states stimulated initiatives to restructure and deregulate the power generation sector of the industry. Although tacitly encouraged by the Federal Energy Regulatory Commission, the movement was by no means nationwide. To this day, many states have never seriously entertained the prospect of restructuring their electricity industries. Restructuring initiatives shared the common goal of lowering costs by enabling consumers' choice of suppliers. For the most part, this involved implementing a common-carrier model of distribution where the distribution, or 'wires' business was unbundled

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[5] Knittel (2003) examines the impact of different regulatory forms on utility performance, with a specific focus on incentive regulation.

from the generation of electricity. Competing generation sources share equal access to customers through common-carrier transmission and distribution networks. These networks have continued to be owned and operated by regulated utilities, or newly formed non-profit Independent System Operators (ISOs).

The generation sector was the focus of liberalization efforts. In states that undertook restructuring, the bulk of existing generation plants were transfered to non-utility generation companies that were no longer regulated at the state level under a cost-of-service paradigm. In states that undertook restructuring, the divestiture of thermal plants was nearly universal amongst investor-owned utilities. The vast majority of utility plants that were not divested were either hydro and nuclear plants, municipal utility owned plants, or plants retained because of special geographic considerations. There were differences in the treatment of vertical integration across states, however, as many utilities transfered generation to non-utility affiliates while others sold the generation outright to new firms.

In many states, changes in regulatory approach accompanied the restructuring and divestiture of generation plants. The introduction of retail choice usually coincided with a freeze on the regulated 'default' rate offered by incumbent utilities. The details of these rate freezes varied. Some provided scope for changes in rates in response to fuel prices and some, like California's, were of variable length. In these states the duration of the rate-freeze was linked to wholesale prices and production costs of non-divested plants, weakening any incentive effects of the freeze.

In short, regulatory restructuring brought about both ownership changes and incentive changes in the generation sector. Ownership changes are straightforward to document, but incentive effects are much more complicated. In the following section we describe alternative strategies for identifying the relative impact of each change.

The majority of plant sales were made between 1998 and 2001. Since that time the restructuring movement has largely lost steam. This is in part a reaction to the California crisis of 2000-01 and in part due to the fact that most of the states where rates were highest, and pressure to restructure the greatest, have already undertaken restructuring. The only major power plant transfers not included in our sample are the Texas plants that were transferred in 2002.

As our focus is on fuel efficiency, we restrict our attention to fossil-fuel fired plants and exclude hydro, nuclear, and renewable generation sources. Our primary data originate from the Environmental Protection Agency's Continuous Emissions Monitoring System (CEMS), which collects hourly data on emissions, fuel consumption, and gross power production. These data are described in more detail in the Appendix. We utilize generating unit-level data for units located in states where there were divestitures as well as neigboring states. Figure 1 displays the 16 states plus the District of Columbia in which there were divestitures, along with the number of divested plants included in our sample as well as the 15 states we include as controls. In total, there are 1890 generating units monitored by CEMS in these states.

The set of units for which the EPA collects CEMS data has expanded over time. We analyze the data from January 1997 to December 2003 and limit our sample to units which began reporting in 1997 or earlier. This excludes 859 units, leaving us with a panel of 1031 units distributed amongst 31 states plus DC. The units that are dropped are much smaller than the remaining units and much more likely to be gas turbines. However, cutting the dataset down leaves the fraction of plants divested virtually unchanged, suggesting that divested units are no more or less likely to be dropped. Table 1 summarizes the total number of generating plants divested by state, as well as the number of plants and units that are included in our sample.

Table 2 summarizes the physical and operating characteristics of both our treatment group of divested plants and our control group of non-divested plants. Divested plants tend to be slightly larger and older than the control group, and much less likely to burn coal. Divested coal units were less likely to have installed emissions reduction equipment, but divested gas units were much more likely to have NOx reducing strategic catalytic reduction (SCR) systems.

The motivations behind restructuring were myriad, but the dominant factor was high rates.[6] Average fuel efficiency was higher in states in which divestitures did not occur, but, discrepancies

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[6] Ando and Palmer (1998) and White (1996) discuss the political economy forces behind electricity industry liberalization.

in rates between states were primarily due to differences in fixed costs, rather than thermal generation performance. Even though average fuel efficiency was lower in states where there were divestitures, it is not obvious that the potential improvement in efficiency was greater in those states. The choice of plants to divest also was driven by factors largely independent of fuel efficiency. The last column of Table 1 lists the percentage of thermal plants in our sample that were divested in each of the states with divestitures. Four states, Ohio, Indiana, Virginia, and Kentucky, had divestiture percentages lower than 60%. All of the plants divested in these states were owned by utilities that operated primarily in neighboring states that undertook restructuring. Thus the selection of divested plants in these states was driven by the regulatory policies of neighboring states and not the choice of the divesting utility. In the remaining states, all of whom did undertake restructuring, the vast majority of plants that were not divested are owned by municipal utilities that are not under the jurisdiction of state regulators and did not liberalize their systems. Thus the choice of plant divestiture was driven by state level policy decisions about restructuring and not left to the discretion of the divesting utility.

3 Empirical Strategy

To examine efficiency changes at power plants associated with divestitures, we would ideally use data on plant outputs and inputs to estimate production functions. We could then examine whether plants move relative to the production frontier after a divestiture or after the regulatory treatment of the plant changes. An ideal data set would include information on all of the broad input categories, including fuel, employees, materials and capital, and would contain data not just on electrical output, but also on the production of other ancillary sercvices such as spinning reserves and voltage support. Unfortunately, we lack that kind of detailed data on both inputs and outputs. Most critically, while there is detailed plant-level data available on the important input categories for the invester-owned utility plants, regulators collect much less data from merchant generators.[7] We can use input data for the plants before they were divested to examine whether

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[7] We are pursuing various possible sources for data on emloyment and material and capital expenditures at merchant plants. Anecdotally, we have heard that merchant plants have lowered employment, sometimes quite

the investor-owned utilities changed their input use in anticipation of the divestiture, but after the divestiture, the set of inputs we can analyze is limited by data availability.

Fortunately, the Environmental Protection Agency collects detailed hourly data on fuel inputs and power production at a vast set of IOU, merchant, municipally-owned and government plants, so we focus on fuel efficiency. By examining fuel use independent of other inputs, we are assuming that power production is Leontief in fuel and other inputs, suggesting that a plant cannot substitute labor or materials for fuel to produce electricity. While there may be a limited extent to which hiring more employees and spending more on materials can help a plant use less fuel, we assume that the primary use of labor and materials in the production process is to keep the plant available. (See Markiewicz Fabrizio, Rose and Wolfram, 2004 for a further discussion of the Leontief assumption.) From a cost perspective, fuel accounts for over 55% of the total costs of generating electricity and around 75% of the operating costs, so major material or capital expenditures would be required to erase the gain from even minor fuel efficiency improvements.

Specifically, we assume that the production function describing the relationship between fuel and electrical output is:

$$Q_{it} = f\left(Fuel_{it}, \epsilon_{it}\right) \tag{1}$$

for unit i in time period t, where Q measures electrical output in MWh and $Fuel$ measures fuel input.[8] $Fuel$ is measured in MMBtus, which gives us common units across fuel types.

Assuming f is monotonic,we can simply invert it to estimate fuel use as a function of output. Also, for consistency with the industry standard for describing fuel use, we divide $Fuel$ by Q and use the $HeatRate$–the inverse of fuel efficiency–as the dependent variable, examining:

$$HeatRate_{it} = g\left(Q_{it}, X_{it}, \varepsilon_{it}\right) \tag{2}$$

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significantly.

[8] We use both hourly and monthly time periods.

We include Q_{it} as an explanatory variable because the relationship between $HeatRate$ and output is not uniform. X_{it} is a set of explanatory variables, such as ambient temperature and unit age.

We take several approaches to using (2) to estimate the relationship between organizational changes, incentives and fuel efficiency. For reasons we discuss more thoroughly below, in the bulk of our work, we describe the relationship between $HeatRate$ and Q by a log-log function and assume that the explanatory variables and the error term enter additively, yielding:

$$ln\left(HeatRate_{it}\right) = \beta_1 ln\left(Q_{it}\right) + \beta_2 X_{it} + \varepsilon_{it} \tag{3}$$

To identify the effects of divestitures, we use the EPA CEMS data on over 1000 generating units, approximately one-third of which were divested. Our data span seven years, and for every unit that was divested, we have at least one full year of observations from before the divestiture. Several sources of variation in the data help us identify a divestiture effect. For all specifications, we include fixed-effects at the unit or sub-unit level. These help control for a whole set of time-invariant unit-specific factors including a unit's technological configurations, age, manufacturer, etc. We then compare the average heat rate before and after the divestiture, controling for Q, X and an average unit effect. Changes in fuel efficiency at non-divested units can help us control for industry-wide trends in fuel efficiency (or in some cases, we use a more limited set of observations and focus on, for instance, trends at coal-fired units). Also, because $HeatRate$ is not well defined when a unit is producing no output, our data set is limited to the set of units that are producing electrical output during a particular time period, so including the non-divested control units helps account for any effect exogenous changes in the set of units would have on average heat rates (that are not picked up by the unit fixed effects).

As discussed above, the divestitures we study effected changes in both the ownership of the plants and in the incentives of the owners. We will try to disentangle the effects of these two forces by examining changes in $HeatRate$ at plants which only faced changes in their incentives–

either plants that were divested to an internal subsidiary of the same company or plants that were not divested but which were subject to a fixed-price regulatory scheme, for instance through a mandatory rate freeze. The difference between the divestiture effect and the incentive effect captures the effects of the ownership change.

Our identification strategy can be summarized by decomposing the error term ε_{it} as follows:

$$\varepsilon_{it} = \gamma_t + \theta_i + \delta_{dt} + \kappa_{kt} + \epsilon_{it} \tag{4}$$

where γ_t, usually estimated as month dummies (*i.e.,* separate dummies for January 2000 and January 2001), capture industry-wide trends, θ_i is a unit-specific fixed effect, δ_{dt} is a dummy variable equal to one at a divested unit in the time periods after the divestiture and κ_{kt} is a dummy variable equal to one at a non-divested unit in the time period after its incentives have changed. The ownership effect is measured as $\delta_{dt} - \kappa_{kt}$. We assume that ϵ_{it} is a mean zero error term, although we allow for the presence of serial correlation in the errors.

We confront several issues in estimating (3). First, as is well-understood by power engineers, the relationship between $HeatRate$ and Q_{it} is non-monotonic and irregular. Figure 2 uses our data to describe this relationship. Specifically, it plots the mean heat rate by output interval for all of the units in our data set. We define the output intervals as follows. First, we define each unit's maximum output (capacity) and minimum threshold by taking the 98th and 2nd percentiles of the unit's observed output. Next we divide the range between the maximum and minimum output into twenty equally-sized intervals for each unit. The top interval is populated by all observations where output is above the 98th percentile and the bottom interval includes all observations for which output was below the 2nd percentile. Figure 2 plots the average $HeatRate$ over each output interval for small and large units, respectively.[9]

As this figure depicts, fuel efficiency improves dramatically ($HeatRate$ drops) as output

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[9] Specifically, we normalized $HeatRate$ for each unit-interval by that unit's zero interval heat rate, added the average (across all units) zero interval heat rate back in and then took the average over all units by interval.

increases from very low levels.[10] Over intervals 2-19, the improvement continues at a much less dramatic pace. At interval 20 (up to the 98th percentile output level), units see an average reduction in their *HeatRates* of approximately 10%, consistent with the idea that units have distinct "sweet spots." Pushing output beyond the 98th percentile output level sacrifices fuel efficiency.

Table 3 demonstrates that the mean unit-specific change in output was negative at divested units and presents some evidence that higher order moments on the distribution of unit-specific output changed with divestitures as well. This suggests that in order to get a reliable measure of the relationship between divestiture and fuel efficiency, we must specify the relationship between fuel efficiency and output with care. Specifically, the first two columns of Table 3 report the coefficients on a dummy variable equal to one in the months following a divestiture from specifications which have $ln(Q)$ on the left-hand side and include unit-fixed effects. Column (1) is estimated on divested units only, while column (2) includes divested units and controls, where the controls help estimate month-year fixed effects. In column (1), the coefficient on *Divestiture* is very small and not significantly different from zero, suggesting that divested units do not change their average monthly output levels after divestiture. The coefficient becomes negative and significant once we add the controls in column (2), suggesting that output at non-divested units is going up over time, so that relative to the controls, divested units are producing about 2.5% less output(standard error equal to 1.0%). Column (3) of Table 3 introduces five measures of state level demand during the month.[11] The coefficient estimate on *Divestiture* becomes slightly less negative, suggesting that one partial explanation for why the divested plants are producing at lower levels after the divestitures is that they operate in areas that happened to have slower increases in demand (*e.g.,* either cooler weather or slower economies).[12]

Because subsequent regressions will examine heat rates by the same types of output intervals

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[10] We limit our sample to hours in which the unit reported producing for the whole hour, primarily because *HeatRates* are extremely noisy in fractional hours. This only excludes about 1% of the observations.

[11] The variables are described more thoroughly in the appendix.

[12] The analysis in Table 3 conditions on the unit producing positive output. We explore the relationship between capacity factors and output below.

that we used to construct Figure 2, the final column on Table 3 examines changes in output by interval. Specifically, as we did to construct Figure 2, we define output intervals relative to each unit's capacity and minimum threshold, defined by taking the 98th and 2nd percentiles, respectively, of the unit's observed output. Next we divide the range between the maximum and minimum output into five equally-sized intervals for each unit. We include the observations for which output was below the 2nd percentile in the first interval and the observations for which output was above the 98th percentile in the fifth interval.[13] Consider the first coefficient in column (4) on the dummy variable $1stInterval * Divestiture$. The negative coefficient suggests that divested units in the lowest output interval produced less output after the divestiture relative to changes at non-divested units. We have also looked at the fraction of months that divested units produced at levels in the various intervals and saw that after the divestitures, they were more likely to be in both the 1st interval and in the 5th intervals. These two observations suggest that the variance of output increased after divestitures.

A related issue is the potential for simultaneity in the relationship between Q and $HeatRate$. This would arise if units adjusted their output to accomodate shocks to their fuel efficiency, for example lowering output when a malfunctioning piece of equipment causes the unit to be less fuel efficient. This is analogous to the simultaneity of inputs problem identified in much of the production function literature.[14] We choose to address the simultaneity problem by instrumenting for Q with electricity demand at the state or more aggregated regional level. This instrument is highly correlated with unit-level output but uncorrelated with information that an individual plant manager has about a particular unit's shock to fuel efficiency.

There are several reasons why we face the potential for endogeneity based on selection. The classic selection story arises if plant managers use a unit's current productivity shock to forecast its future productivity and retire it if the shock is below a threshold value that may depend on

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[13] Note that the capacity and minimum thresholds are defined by taking the 98th and 2nd percentiles over the hourly data but observations for Table 3 are assigned to intervals based on their average output over the month.

[14] See Griliches and Mairesse (1998) for an overview of the issue and survey of various approaches to dealing with it. Recent papers by Olley and Pakes (1996) and Levinsohn and Petrin (2003) propose structural approaches to addressing simultaneity. Ackerberg and Caves (2003) compares and critiques the approaches proposed by them.

input levels. We suspect that this type of selection is not a large problem for us. For one, there appear to have been very few retirements over our sample period. Of the 1031 units present in 1997, we have observations on all but 80 of them from 2003. It is likely that not all of these 80 units were retired since some units run very infrequently suggesting that using a single year of not running to imply a retirement is too aggressive. Further, shocks to $HeatRate$ are likely to play only a small part in the decision to retire an electric generating unit. The magnitude of fixed between-unit differences in $HeatRate$ (determined by the age, technology and fuel type of a unit) swamp within-unit shocks.

A related feature of the data is the fact that approximately 40 thermal plants that were divested had been on cold standby, near retirement, for several years prior to their divestiture. While the question of why they were purchased is intriguing, these plants never appeared in the CEMS data, so they are selected out of our data set the same way any other plant on cold standby in the late 1990s would have been.

Neither the simultaneity nor the classic selection problem are unique to our context and both have been discussed extensively in the production function literature. While many papers have estimated production or cost functions for electric generating plants, from the classic analyses in Nerlove (1963) and Christensen and Greene (1976) to very recent work such as Kleit and Terrell (2001) and Knittel (2002), electricity industry studies typically have not explicitly treated either simultaneity or selection problems.[15]

It is also possible that the decision to divest a plant is correlated with potential fuel efficiency improvements. As discussed above, the decision about whether or not utilities within a particular state would be asked to divest their plants was made as part of a broader movement towards industry liberalization. For a variety of reasons, the push towards industry liberalization was stronger in some states than in others. In most of the states where there were divestitures, nearly all of the units were divested (and in some cases literally all of the units with certain characteristics, *e.g.,* above a certain size, were divested). We rely on the assumption that

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[15] Markiewicz Fabrizio, Rose and Wolfram (2004) also addresses the potential for simultaneity and selection.

whether or not a state embarked on an industry liberalization program was not a function of potential heat rate improvements at the thermal units within the state.[16] In future work, we could deal with this potential selection issue more formally by instrumenting for divestiture with state-level variables that influenced the political economy of restructuring but that would be uncorrelated with potential changes in unit-level efficiency. One plausible instrument is the average retail price in 1996.

A more nuanced potential selection issue arises around the type of divestiture. In five of the states where there were divestitures, some of the utilities transferred the plants to internal unregulated subsidiaries (what we will refer to as an internal divestiture) while other utilities sold their plants to entirely new companies (external divestitures). In the remaining 14 states where there were divestitures, regulators discouraged internal transfers and all the divestitures were external. One concern is that in the five states that permitted internal transfers, utilities with private information about low cost ways to improve heat rates at their units would be more likely to opt to transfer them to an internal subsidiary. If this were true, we would expect internal transfers to be associated with much larger efficiency improvements than external transfers. Internal transfers and external transfers differ in another respect, however, since an external transfer leads to more of the organizational dispruption associated with an outright ownership transfer. We assume that in states that strongly discouraged internal transfers, the selection effect is absent, so that measuring efficiency improvements at these plants captures a pure external transfer effect absent any selection effect. By comparing external transfers where there were no internal transfers to external transfers where there were both types of transfer, we can assess the extent of the selection problem. Also, we can make some headway at identifying the efficiency effect from an ownership transfer separately from the efficiency effects from changes in incentives.

Specifically, we will decompose δ_{dt} as follows:

$$\delta_{dt} = \delta_{dt}^{internal} + \delta_{dt}^{externalboth} + \delta_{dt}^{externalonly} \tag{5}$$

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[16] Recall that our estimation includes unit-fixed effects, so the possibility that restructuring movements were stronger in states where plants had lower average fuel efficiency would not create bias in our results.

Where $\delta_{dt}^{internal}$ is a dummy variable equal to one at units that are divested through internal transfers in time periods after the transfers, $\delta_{dt}^{externalboth}$ is a dummy variable equal to one at units that are divested through external transfers in states where both types of transfer were allowed in time periods after the transfer and $\delta_{kt}^{externalonly}$ is a dummy variable equal to one at units that are divested through external transfers in states where there were only external transfers in the time periods after the transfer. We conjecture that $\delta_{dt}^{internal}$ will capture both a positive efficiency effect because of higher powered incentives and any positive efficiency effect due to selection. $\delta_{dt}^{externalboth}$ will capture an incentive effect, an ownership effect (possibly positive or negative) and a negative efficiency effect due to selection. $\delta_{dt}^{externalonly}$ will capture only the incentive and ownership effects, so assessing whether $|\delta_{dt}^{externalboth}| \geq |\delta_{dt}^{externalonly}|$ will give us some indication of how big the selection effect is.[17]

The effects that we have identified so far suggest that internal transfers should experience the same average improvements as non-divested units facing incentive regulation (*i.e.,* $\kappa_{kt} = \delta_{dt}^{internal}$. This raises the question of why one organizational form was chosen in some states and not others.

4 Results

Tables 4 through 7 present a number of specifications of equation (3). In all but Table 5, we rely on monthly data, so that $ln(HeatRate)$ is equal to the log of the average heat rate across all hours in a month when the unit was operating and $ln(Q)$ is equal to the log of the average output at the unit over the month. Table 5 uses observations at the hourly level. For all specifications, the standard errors are clustered by unit to allow for serial correlation over time within a unit.

In the first two columns of Table 4, we fit a log-log relationship between $HeatRate$ and Q and include a dummy variable $Divestiture$ equal to one in the months following the transfer. It is equivalent to δ_{dt} described above and is equal to one for both internal and external transfers.[18] The first column uses only observations on units that were divested at some point over the sample

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[17] Note that we are assuming that utilities did not influence the policy decisions about which types of transfers should be allowed.

[18] Specific information on the dating of the divestitures is described in the Appendix.

period, so the coefficient on $Divestiture$ is simply the average percent change in $HeatRate$ at divested units after the transfer. Column (2) includes observations on control units that were not divested and we estimate month-year fixed effects (γ_t). As the coefficients on $Divestiture$ across the two columns are very similar, it appears that there were not important temporal trends in $HeatRate$ that the control units help us identify.[19] Both coefficients suggest $HeatRate$ reductions of approximately 2% after divestitures (with standard errors of 1%).

Columns (3) and (4) of Table 4 use a richer description of the relationship between $HeatRate$ and Q and also allow the divestiture effect to vary by how much output the units produce relative to their capacity. Using the same five output intervals as we did in Table 3, we allow both the divestiture effect and the coefficient on $ln(Q)$ to vary by interval. The specifications in columns (3) and (4) also included five fixed effects per unit–one corresponding to each interval. The coefficient estimates on the $Interval * Divestiture$ variables suggest that most of the efficiency gains have occurred when monthly-average output levels were high. The coefficient estimates on the $Interval * ln(Q)$ variables suggest that the relationship between $ln(HeatRate)$ and $ln(Q)$ are roughly similar, except more steeply negative on the last interval. In light of the distinct dip in Figure 1 around the 98th percentile output, we estimated specifications that included a dummy variable for units being at the "sweet spot." While the coefficient on this dummy was negative and significant, the coefficient on the divestiture variable was essentially unchanged. Repeating this exercise with the hourly observations may not yield the same result. Two units with monthly average output near their sweet spots presumably would have very different average $HeatRates$ if one has stayed at the sweet spot all month and the other has produced at fluctuating output levels.

Columns (5) and (6) of Table 4 present instrumental variable estimates on a specification analogous to the ones in Columns (1) and (2). The instruments we use are the five demand variables used as controls in Table 3 plus, in column (6), interactions of these variables with

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[19] We have also estimated specifications where we allow the month-year-fixed effects to vary by region of the country and the results are very similar to those reported.

the *Divestiture* dummy variable. [20] Except for the interactions with the *Divestiture* dummy, the first-stage is analogous to the specification in Column (3) of Table 3. As we can see there, the demand variables have the expected signs. The interactions with the *Divestiture* dummy generally suggest that units are more responsive to demand after a divestiture, though they are not all precisely estimated. For the divested units only, Column (5), the instruments are quite good: The F-statistic from the test that all the instruments are zero is F(5,19168)=23.21. For the specification including control units, the instruments are somewhat weaker: The F-statistic from the test that all the instruments are zero in the first stage for Column (6) is F(10, 63769) = 9.43. Consistent with the classical simultaneity story, the coefficient on $ln(Q)$ attenuates to zero, by a small amount in Column (5) but a much larger amount in Column (6). Since divested units generally produced less after they were divested (see Table 3), the smaller coefficient on $ln(Q)$ causes the coefficient on *Divestiture* in Column (6) to fall somewhat substantially, but not at all in Column (5). Part of the difference between Columns (5) and (6) is due to the fact that we had to use adjoining state data for some of the states where control units are located, causing the instruments to be weaker and the coefficients to be imprecisely estimated. We are currently trying to grasp a full understanding of the differences between Columns (5) and (6).

Table 5 reports results from specifications analogous to those in columns (1) and (3) of Table 4 but uses the data at the hourly level for estimation. The coefficient estimates are almost identical to those reported in Table 4, but they are more precisely estimated. This is consistent with our expectations. Since the divestiture effect does not vary at the sub-month level in any meaningful way, we expect the coefficient on the divestiture variables to be approximately the same as those reported in Table 4. Our estimates are more precisely estimated, presumably since hour-to-hour changes in Q are better predictors of hour-to-hour movements in $HeatRate$ than are monthly averages.[21] Note also that the coefficient on $ln(Q)$ is smaller than in Table 4, suggesting that hour-to-hour changes in $ln(Q)$ are driven more by exogenous factors than are month-to-month

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[20] The demand data we currently have for 2003 are problematic, so all specifications involving the monthly state demand variables are estimated on 6 years of data instead of 7. Also, the demand data are problematic for several of the control states, so we use data from adjoining states.

[21] In future work, we will add a variable reflecting the hourly ambient temperature, which will likely increase the precision of our results even more.

changes in output. Consistent with Table 4, the divestiture effect appears to be most pronounced at higher output levels. Note also that there are many more hourly than monthly observations in the fifth interval.[22]

Table 6 presents estimates of basic specifications analogous to the one presented in column (2) of Table 4 that are estimated on a subset of units with common characteristics. The only substantial differences we see across unit types is that efficiency improvements were on average higher at coal plants and smaller at plants built since 1978. Consistent with the results in column (5) suggesting that large units saw the same percentage improvements as did all units, when we ran a specification on the hourly data analogous to column (1) of Table 5 and weighted by unit capacity, the results were very similar to those reported, suggesting efficiency improvements of 2.5% on average.

Table 7 decomposes the divestiture effect following the logic used to build up equations (4) and (5) above. In the first column of the table, we introduce the variable $IncentiveRegulation$ equal to one both in states where there were rate freezes but no divestitures and in states where there were rate freezes preceding at least some of the divestitures.[23] The coefficient on $IncentiveRegulation$ suggests that $HeatRates$ fell by nearly 2% at plants who faced increased incentives to conserve their fuel costs. The coefficient on $Divestiture$ becomes slightly more negative, since the set of units to which the divested units are being compared no longer includes the units facing higher-powered incentives. The coefficients on $Divestiture$ and $IncentiveRegulation$ are statistically indistinguishable from one another.

Column (2) of Table 7 distinguishes three different types of divestitures: those to external firms in states where only external transfers took place, those to external firms in states where there were both internal and external transfers and internal transfers. First, the coefficient estimates provide little evidence of selection since the coefficient on the $External\_Only$ variable is smaller in magnitude and statistically indistinguishable from the coefficient on the

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[22] The fraction of observations in interval 5 is 40.5% in Table 5 and 18.0% in Table 4. See the notes to each table.

[23] In future work, we will set the dummy to zero for the municipally and government-owned units from these states, since their incentives did not change with the regulated rate freezes for the investor-owned utilities.

External_Both variable. The large negative coefficient on the *Internal* variable relative to the two external divestitures suggests that most of the gains were at these plants, suggesting that the incentive effect is quite powerful and that there may be inefficiencies associated with divestitures to external firms that counteract the incentive effect. This would explain why the coefficient on *External_Both* is essentially zero. We will explore these patterns in more detail in future work. One point of caution in interpreting the coefficients in Table 7 is that the types of plants represented by the three different divestiture variables are quite different. For instance, states with both internal and external transfers had many more coal units. When we limit the set of plants to coal plants, the divestiture effect is more consistent across all three types of transfers, though still higher for internal transfers.

The last column of Table 7 considers the hypothesis that any gains seen at divested firms were simply making up for degredation that the investor-owned utilities let happen at the plants they suspected they might soon divest. We do this by including two new variables. *TimetoDivestiture* measures the time until the divestiture in months, equal to one in the month before the divestiture, twelve when the divestiture was exactly one year away, etc. *TimesinceDivestiture* measures the months since the divestiture. If the IOUs had deferred maintenance and let *HeatRates* fall in anticipation of the divestitures, we would expect the coefficient on *TimetoDivestiture* to be negative. Instead, it is estimated to be very close to zero, suggesting that there was little change in the heat rates before the divestitures. The coefficient on *TimesinceDivestiture* is negative, suggesting that efficiency improvements at divested plants take time to materialize.[24]

While the results so far have focused on the effects of market liberalization on *HeatRate*, we were able to obtain data on several other variables that may have been affected by the new incentives. Table 8 explores the effects of *Divestiture* on *Net/GrossOutput* and Table 9 considers the effects of *Divestiture* on capacity factors, the number of starts and the number of forced outages at a unit. Consider first Table 8. Plants use the difference between gross and

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[24] The coefficient on *TimesinceDivestiture* is negative and of very similar magnitude when we limit the sample to coal units, implying that differences in the timing of divestitures of different types of plants are not the only sources of variation identifying the coefficient on *TimesinceDivestiture* in the full sample.

net output, on average in our sample about 9% of gross output, to power machinary such as pollution control equipment, fans, coal pulverizers, etc. We construct the variable at the plant level because the net data are only available at this level. Also, $Net/GrossOutput$ is only really defined at the plant level, since some of the plant's native load could not meaningfully be assigned to one unit or another. The Data Appendix describes the construction of the variable in more detail. Two issues are worth noting in the text. A number of plants have small units that are run infrequently and that are not included in the CEMS data set. We exclude all plants for which the CEMS data never contain all units. This accounts for over 70% of the units, but only about 60% of the plant-month observations. Even after this cut, there are still about 500 observations where the $Net/GrossOutput$ variable is nonsensical–either less than zero or greater than one. We determined using conventional regression diagnostic tools that our coefficient estimates were sensitive to the 100 grossest outliers, so the results reported are limited to observations where $Net/GrossOutput$ is between zero and 1.

The results in the first two columns of Table 8 examine the effect of $Divestiture$ on plant $Net/GrossOutput$ using ordinary least squares. The sample in the first column is limited to the units that were at some point divested while the second column introduces the control units. We control for $ln(Q)$ in case the power use of the ancillary machinary does not scale one-for-one with gross output. The positive coefficient on $ln(Q)$ suggests that plants become slightly more efficient in converting net to gross output at higher gross output levels. In neither case does there appear to be a significant impact of $Divestiture$ on plant efficiency. The specifications in Columns (1) and (2) may reflect a simultaneity bias if plants run less when they are less efficient at converting gross output to net, so Columns (3) and (4) report results where we have instrumented for $ln(Q)$. While the coefficients on $ln(Q)$ go down slightly, most obviously in the specifications that include the controls, the coefficients on $Divestiture$ continue to be very close to zero.[25]

Table 9 explores the relationship between divestitures and some simple operating statistics. Columns (1) and (2) demonstrate that $CapacityFactors$ came down after divestitures, consistent

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[25] In other specifications, we limited the sample to units without SCRs and still found no effect of $Divestiture$ on $Net/GrossOutput$.

with the findings in Table 3 that output also went down at divested plants.[26] Interestingly, when we allow the effect to vary across *Internal*, *External_Only* and *External_Both* companies, the coefficient on *Internal* is small and insignificantly different from zero, suggesting that these firms did not reduce output. In Columns (3) and (4), the dependent variable is the number of starts a unit performed per 100 operating hours. Although the coefficient estimates are not significantly different from zero, they suggest that divested units perform about 7% more starts on average after the transfer. The results in Columns (5) and (6) suggest that divested units experience fewer forced outages after the transfer.[27] While these results are interesting in their own right, we will explore possible links between the patterns they suggest and unit efficiency more thoroughly in the future. It is possible, for instance, that starts require operator effort that IOUs had no incentive to exert. If divested units are willing to do more starts, they may operate at lower capacity factors and less frequently at the low end of their capacity range, where heat rates are higher. To guage the full efficiency effects of this pattern, we need to fully account for the costs of starts.

5 Conclusion

The restructuring of the electric utility industry was intended to provide strong incentives and more effective market signals to promote efficient construction and operations of generating plants. The divestiture of regulated power plants, comprising about 20% of the nation's capacity, was a central component of these changes. We study one important aspect of plant operations, fuel efficiency, by utilizing detailed hourly production data from both divested and non-divested plants. Fuel costs are the dominant operating expense at fossil-fuel power plants.

Our results indicate that operations at divested plants did change relative to their utility-owned counterparts. Generation declined slightly at divested plants, but the relative amount of

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[26] Because the sign and magnitude of these results were highly sensitive to the approximately 400 observations for which *CapacityFactor* is greater than 1, we have excluded them. The results reported are consistent with specifications that remove outliers using conventional regression diagnostic tools.

[27] For the results in Columns (3)-(6), the coefficient estimates fall by about 50% in absolute value but become much more precisely estimated when we remove outliers using regression diagnostic tools.

energy produced while plants operated at more efficient high output levels increased. Most importantly, heat rates, a measure of fuel use per MWh, declined by roughly 2% at divested plants relative to our control groups - even after controlling for the specific output levels. These improvements also appear to be concentrated in the high output range of the plants. Thus divested plants operated at more efficient levels, and those levels themselves became more efficient.

To place these results in context, consider that the average unit heat rate in states that pursued divestiture was 11,900 MMBtu/kWh, and that the EIA reports the average cost of all fossil fuels in the U.S. was around $2.50/MMBtu during 2004. Thus plant level heat rate changes saved roughly $0.60/MWh. Total U.S. electricity production from fossil fuels was around 2.7 trillion MWh in 2003. Roughly 1/3, or 900 million MWh, of that production was in divested states. This implies a fuel cost saving of approximately $550 million during 2003. Environmental costs, not considered here, would further increase the savings from heat rate reductions. Note that these calculations do not include other costs. To the extent that fuel efficiencies stem from increased non-fuel expenditures, net savings will be lower.

The improvements appear to be driven mostly by changes in the incentives of plant owners. Similar, though slightly smaller, improvements were seen at utility-owned plants in states that imposed rate freezes during the same time period. Further, the efficiency improvements in divested plants are dominated by the gains made at plants that were transferred to unregulated affiliates of the selling utility. Thus, ownership change appears to play a small or possibly even negative role in the efficiency story.

These changes are by no means the only factors to consider when evaluating the impacts of restructuring. Many observers believe that the largest potential benefits from restructuring will be improved investment decisions. Other evidence indicates that savings in labor costs may be proportionately even greater than those in fuel costs. On the other hand, there is also evidence that the exercise of market power negatively impacted the allocative efficiency of production in some states. Still, these results indicate that restructuring has had a positive impact on the fuel efficiency of power plants, and that these gains accrued across many fuel and technology types.

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Data Appendix

Our primary data source is BaseCase, a database produced by Platts (see www.Platts.com). Platt's compiles data on power plant operations and characteristics from numerous public sources, performs limited data cleaning and data analysis and creates cross references so that the data sets can be linked by numerous characteristics (e.g. power plant unit, state, grid control area, etc.). We relied on information from BaseCase for the following three broad categories.

Unit Operating Profile

BaseCase contains hourly power-plant unit-level information derived from the Continuous Emissions Monitoring System (CEMS) database collected by the Environmental Protection Agency. The EPA assembles this detailed, high quality data to support various emissions trading programs. The CEMS data are collected for all fossil-fueled power plant units that operate more than a certain number of hours a year. The dataset contains hourly reports on heat input, gross electricity output and pollutant output. We calculate the Heat Rate by dividing heat input (measured in mmBtus) by gross electricity output (measured in MWh). We limit the sample to hours when units were operating for the entire hour, and by construction of the variable Heat Rate, to hours in which the unit was producing positive gross electricity output.

We also rely on the analysis Platt's performs on the CEMS data to determine forced outages.

Net output

Data on the net output of power plants is also taken from BaseCase. These data are compiled from survey data collected by the Energy Information Administration (EIA) and reported in the EIA's form 906. The difference in data created several shortcomings. First data are only reported monthly at the plant level, rather than the unit level. Nearly 70% of the plants in the data set contain units that are not monitored by CEMS. For these plants a reasonable evaluation of net to gross output is not possible. Even after eliminating these plants, there remain plant-months where the survey-based net output is greater than the CEMS measured gross output, a physical impossibility. In the results we report here, we restrict our sample to plant-month observations where the net-to-gross ratio falls between 0 and 1.

System-level Demand Characteristics

Data on system level demand are taken from the PowerDat database, also compiled by Platts. These data report the monthly minimum, maximum, mean,and standard deviation of load by utility, as well as the average daily maximum over a month. Platts compiles this information from survey data collected by the EIA and reported in its form 714.

Unit Characteristics

Unit characteristics are taken from the "Base Genearting Units" and "Estimated Fossil-Fired Operations" data sets within BaseCase.

We merged data from BaseCase to several additional sources.

Ambient Temperature-Hourly

We obtained hourly temperature data by weather station from the Unedited Local Climatological Data Hourly Observations data set put out by the National Oceanographic and Atmospheric Administration. Further documentation is available at:

http://www.ncdc.noaa.gov/oa/documentlibrary/ulcd/lcdudocumentation.txt

We calculated the Euclidean distance between each weather station-power plant combination, using the latitude and longitude for each power plant and for each weather station. Then, for each month, we found the weather station closest to each power plant that had more than 300 valid temperature observations. For hours when the temperature was missing, we interpolated an average temperature from adjoining hours.

Divestiture Information

We take information on divestitures from the, "Electric Utility Plants That have Been Sold and Reclassified as Nonutility Plants" table in the Energy Information Administration, Electric Power Monthly, March (various years). We use information on the name of the plant divested, the buying and selling entities and the divestiture date. We cross-checked the divestiture dates against EIA Form 906, which requires each plant owner to report monthly production. We checked whether the change in the identity of the plant-owner reporting to form 906 coincided with the divestiture dates reported in Electric Power Monthly. The majority of any discrepencies were less than 2 months. As a precaution we drop hourly observations from a plant for the 45 days previous and 15 days following the divestiture date reported in Electric Power Monthly.

As of December 2001, divestitures have taken place in 24 states. In 2002 and 2003, the only divested units were either in Texas, which we exclude from our sample, or were nuclear power plants.

Figure 1: Divesture and Control States

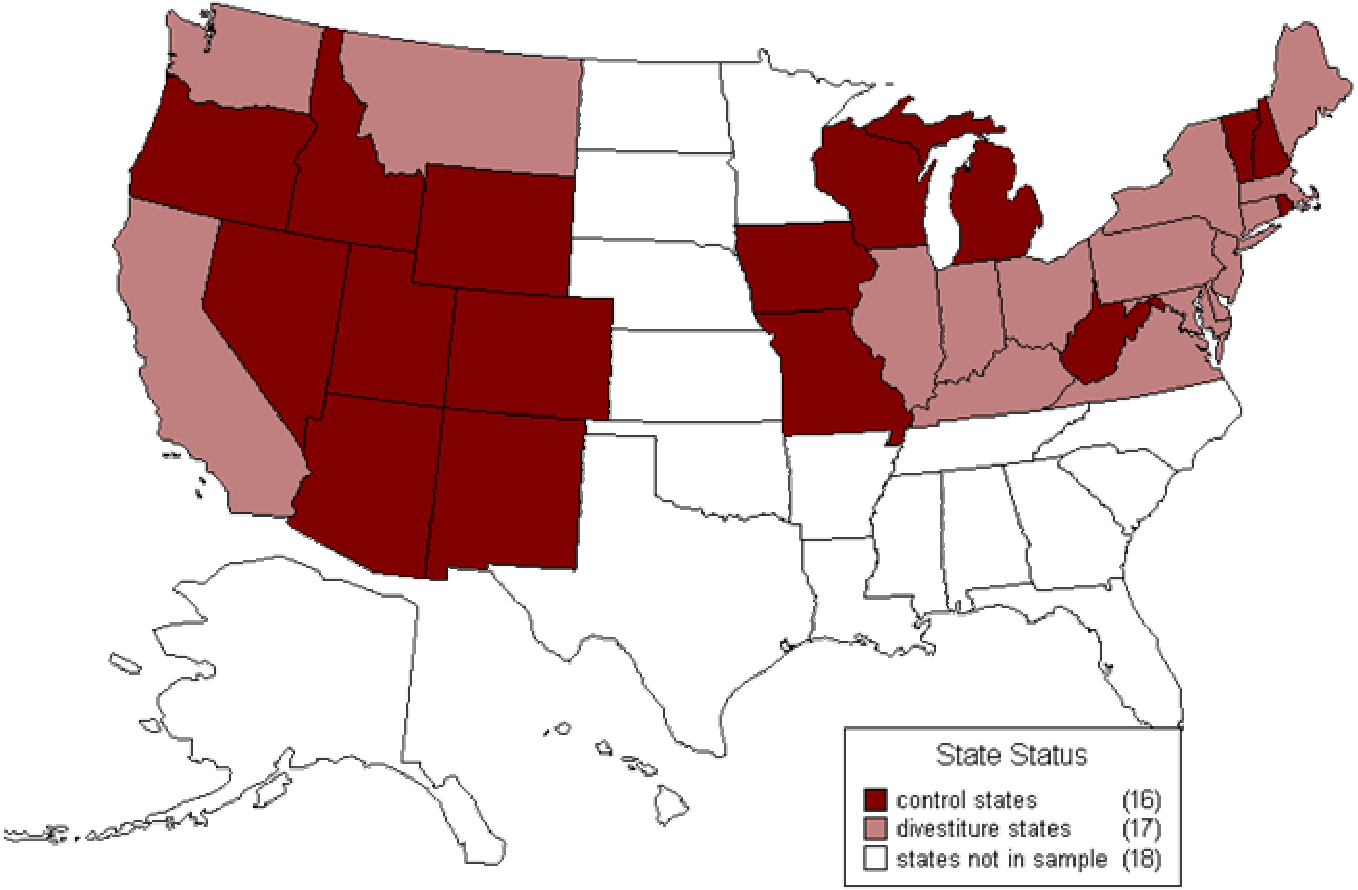

Figure 2: Unit Heat Rate Profiles

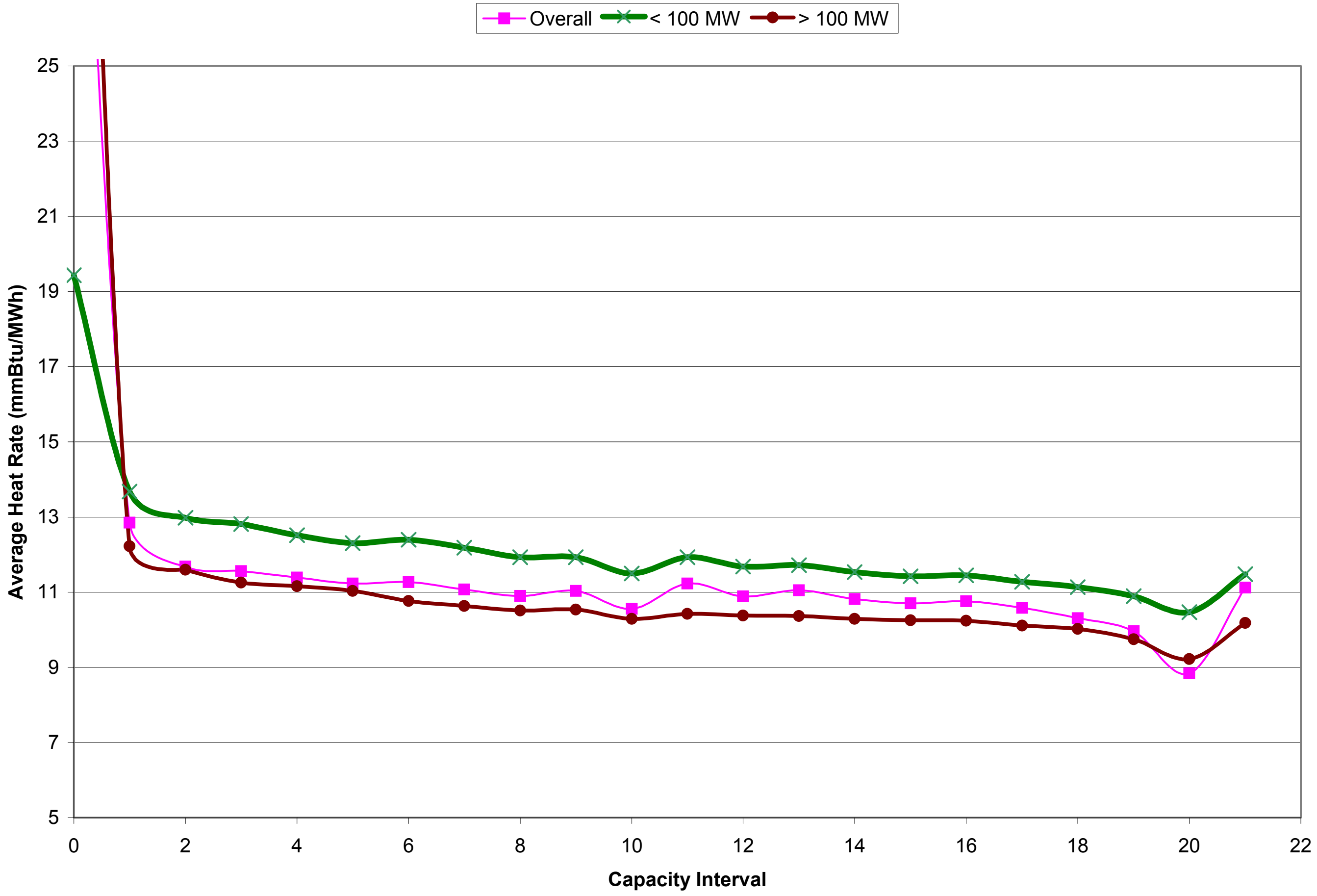

Table 1: State-by-State Summary of Divestitures

State	# of Plants (Units) Divested		Divestiture Date (Average months since 1/1998)	Divestitures as a Fraction of Total 2003 Obs.
	Total	Our Sample		
California	29	15 (47)	10	.74
Connecticut	13	6 (16)	23	1
DC	2	1 (2)	40	1
Delaware	7	2 (7)	39	.80
Illinois	37	16 (34)	23	.62
Indiana	2	1 (2)	9	.03
Kentucky	5	5 (8)	8	.14
Massachusetts	34	6 (17)	10	.89
Maryland	19	11 (29)	35	1
Maine	3	2 (7)	16	1
Montana	14	2 (5)	24	.83
New Hampshire	3	0	--	--
New Jersey	27	6 (16)	32	.72
New York	32	14 (41)	22	.69
Ohio	2	1 (2)	29	.03
Pennsylvania	60	21 (57)	28	.94
Rhode Island	1	0	--	--
Virginia	3	1 (5)	37	.19
Vermont	5	0	--	--
Washington	2	1 (2)	29	1
West Virginia	1	0	--	--

Additional control states include: Arizona, Colorado, Idaho, Iowa, Michigan, Missouri, New Mexico, Nevada, Oregon, Utah, Wisconsin and Wyoming.

Table 2: Unit Characteristics: Divested Units versus Controls

Variable	*DIVESTITURES*		*CONTROLS*		Difference in Means (t-statistic)
	Mean	Std. Dev.	Mean	Std. Dev.	
Size (MWs)	271	12	240	12	31
					(1.57)
% Coal	50	2.8	78	1.5	-28**
					(-9.41)
% Gas-Steam Turbines	28	2.5	11	1.2	17**
					(6.87)
% Gas-Gas Turbines	4.6	1.2	5.5	.9	-1
					(-.52)
Installation Year	1963	1	1966	.5	-2.5**
					(-2.87)
% of coal with scrubbers	15	3	25	2	-9**
					(-2.50)
% of coal with SCR	5.5	2	5.5	1	~0
					(.07)
% of gas with SCR	17	3.7	2.5	1.5	14.5**
					(3.79)
% re-rated after 1997	4.9	1.2	3.4	.7	1.15
					(1.15)
Total Units	327		704		

** Significant at .05 level or better

Table 3: Output as a Fraction of Unit Capacity

Dependent Variable: ln(*Q*)

	Unit-Month Observations			
	Only Divested Units	With Controls	With Controls	With Controls
Divestiture	0.006	-0.025**	-0.019*	
	(0.010)	(0.010)	(0.010)	
*1st Interval*Divestiture*				-0.076
				(0.063)
*2nd Interval*Divestiture*				0.006
				(0.006)
*3rd Interval*Divestiture*				-0.003
				(0.003)
*4th Interval*Divestiture*				-0.001
				(0.003)
*5th Interval*Divestiture*				0.010***
				(0.003)
ln(State Average Load)			0.084	0.107**
			(0.138)	(0.049)
ln(State Max Load)			0.301***	0.048***
			(0.047)	(0.014)
ln(State Minimum Load)			-0.326***	-0.048***
			(0.042)	(0.015)
Ln(State Standard Deviation Load)			-0.163***	-0.012
			(0.036)	(0.012)
ln(State Average Daily Maximum Load)			0.149	-0.091*
			(0.140)	(0.052)
Month-Year Fixed Effects	No	Yes	Yes	Yes
Unit or Unit-Interval Fixed Effects	Unit	Unit	Unit	Unit-Interval
R^2	0.88	.94	.99	.99
N	19,858	65,431	65,431	65,431

Standard errors (in parentheses) are robust to serial correlation within a unit.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 4: The Effect of Divestitures on Fuel Efficiency-Monthly Observations

Dependent Variable: ln(*Heat Rate*)

	OLS				IV	
	Only Divested Units	With Controls	Only Divested Units	With Controls	Only Divested Units	With Controls
Divestiture	-0.022**	-0.021**			-0.022**	-0.013
	(0.010)	(0.010)			(0.009)	(0.009)
*1st Interval*Divestiture*			-0.003	-0.001		
			(0.039)	(0.039)		
*2nd Interval*Divestiture*			-0.009	-0.010		
			(0.021)	(0.022)		
*3rd Interval*Divestiture*			-0.026*	-0.025*		
			(0.015)	(0.015)		
*4th Interval*Divestiture*			-0.008	-0.008		
			(0.014)	(0.014)		
*5th Interval*Divestiture*			-0.027***	-0.024***		
			(0.008)	(0.009)		
ln(Q)	-0.405***	-0.364***			-0.380***	-0.106
	(0.024)	(0.018)			(0.068)	(0.120)
1st Interval ln(Q)*			-0.343***	-0.327***		
			(0.041)	(0.032)		
2nd Interval ln(Q)*			-0.337***	-0.282***		
			(0.075)	(0.044)		
3rd Interval ln(Q)*			-0.285***	-0.310***		
			(0.049)	(0.041)		
4th Interval ln(Q)*			-0.356***	-0.375***		
			(0.077)	(0.039)		
5th Interval ln(Q)*			-0.529**	-0.778***		
			(0.271)	(0.136)		
Month-Year Fixed Effects	No	Yes	No	Yes	No	Yes
Unit or Unit-Interval Fixed Effects	Unit	Unit	Unit-Interval	Unit-Interval	Unit	Unit
R^2	.56	.54	.64	.64		
N	22,506	75,066	22,506	75,066	19,501	64,882

Heat Rate measures the inverse of fuel efficiency. Standard errors (in parentheses) are robust to serial correlation within a unit.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Interval	Fraction of Obs
1	5.1%
2	13.4%
3	28.7%
4	34.7%
5	18.0%

Table 5: The Effect of Divestitures on Fuel Efficiency-Hourly Observations

Dependent Variable: ln(*Heat Rate*)

	OLS	
	Only Divested Units	Only Divested Units
Divestiture	-.022***	
	(.006)	
*1st Interval*Divestiture*		-0.017**
		(0.007)
*2nd Interval*Divestiture*		-0.016
		(0.010)
*3rd Interval*Divestiture*		-0.009
		(0.007)
*4th Interval*Divestiture*		-0.021***
		(0.006)
*5th Interval*Divestiture*		-0.023***
		(0.006)
ln(Q)	-.279***	
	(.015)	
1st Interval ln(Q)*		-0.512***
		(0.020)
2nd Interval ln(Q)*		-0.204***
		(0.014)
3rd Interval ln(Q)*		-0.087***
		(0.015)
4th Interval ln(Q)*		-0.076***
		(0.017)
5th Interval ln(Q)*		-0.159***
		(0.039)
Month-Year Fixed Effects	No	No
Unit or Unit-Interval Fixed Effects	Unit	Unit-Interval
R^2	0.45	0.81
N	10,863,323	10,863,323

Heat Rate measures the inverse of fuel efficiency. Standard errors (in parentheses) are robust to serial correlation within a unit.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Interval	Fraction of Obs
1	19.6%
2	12.1%
3	11.8%
4	16.0%
5	40.5%

Table 6: The Effect of Divestitures on Fuel Efficiency by Category-Monthly Observations

Dependent Variable: ln(*Heat Rate*)

	OLS				
	Gas Units	Coal Units	Pre-1960 Units	Post-1978 Units	Units > 200 MW
Divestiture	-0.052*	-0.026**	-0.023*	-0.016	-0.022
	(0.027)	(0.010)	(0.013)	(0.042)	(0.018)
ln(Q)	-0.330***	-0.374***	-0.266***	-0.505***	-0.451***
	(0.025)	(0.029)	(0.025)	(0.047)	(0.029)
Month-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
R^2	0.58	0.41	0.60	0.48	0.49
N	10027	55706	29230	13023	31483

Heat Rate measures the inverse of fuel efficiency. All specifications include unit fixed effects and are estimated on a data set including both the divested units and the controls. Standard errors (in parentheses) are robust to serial correlation within a unit.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 7: Decomposing the Divestitures Effect-Monthly Observations

Dependent Variable: ln(*Heat Rate*)

	OLS		
	All Units	All Units	All Units
Divestiture	-0.024**		-0.002
	(0.011)		(0.014)
External Only		-0.003	
		(0.013)	
External Both		-0.023	
		(0.018)	
Internal Subsidiary		-0.067***	
		(0.024)	
Incentive Regulation	-0.019**	-0.019*	
	(0.010)	(0.010)	
Time to Divestiture			~0
			(0.001)
Time since Divestiture			-0.001*
			(0.0006)
ln(Q)	-0.364***	-0.364***	-0.364***
	(0.018)	(0.018)	(0.018)
Month-Year Fixed Effects	Yes	Yes	Yes
R^2	0.54	0.54	0.54
N	75066	75066	75066

Heat Rate measures the inverse of fuel efficiency. All specifications include unit fixed effects and are estimated on a data set including both the divested units and the controls. Standard errors (in parentheses) are robust to serial correlation within a unit.
External Only is equal to one for divestitures to external firms if the unit is in a state where only external divestitures occurred.
External Both is equal to one for divestitures to external firms if the unit is in a state where both internal and external divestitures took place.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 8: The Effect of Divestitures on Ratio of Net Output to Gross Output-Plant-Level Monthly Observations

Dependent Variable: ***Net/Gross Output***

	OLS		IV	
	Only Divested Units	With Controls	Only Divested Units	With Controls
Divestiture	-0.002	0.001	0.005	~0
	(0.004)	(0.005)	(0.010)	(0.003)
ln(Q)	0.024***	0.030***	0.024	0.016
	(0.006)	(0.005)	(0.022)	(0.014)
Month-Year Fixed Effects	No	Yes	No	Yes
R^2	0.15	0.66		
N	2,267	11,482	2,267	11,482

All specifications include plant fixed effects. Standard errors (in parentheses) are robust to serial correlation within a plant. Observations are at the plant-month level. Sample limited to plants for which the CEMS data covers all units.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 9: The Effect of Divestitures on Starts and Forced Outages-Unit-Level Monthly Observations

Dependent Variable:	Capacity Factor		Starts per 100 Operating Hours		Forced Outages per 100 Operating Hours	
	Only Divested Units	With Controls	Only Divested Units	With Controls	Only Divested Units	With Controls
Divestiture	-0.024***	-0.038***	0.095	0.097	-0.257*	-0.109
	(0.008)	(0.006)	(0.082)	(0.128)	(0.138)	(0.106)
Month-Year Fixed Effects	No	Yes	No	Yes	No	Yes
Mean of Dependent Variable	0.56		1.31		.08	
R^2	0.66	0.68	0.19	0.12	0.01	0.01
N	22,305	74,215	22,572	75,132	22,572	75,132

Standard errors (in parentheses) are robust to serial correlation within a unit. All specifications include unit fixed effects.