Comparing Changes in Operational Productivity and Financial Productivity of Electric Utilities in a Competitive Environment

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Abstract

This paper defines operational productivity as a physical measure of output in the numerator and a physical measure of input in the denominator. Financial productivity would have either the input or the output expressed in monetary terms. This paper measures change in Total Factor Productivity of investor owned utilities associated with changes in the non-utility generators' market share and industry reorganization. It measures these effects using both operational productivity and financial productivity as the dependent variable. It finds that the two definitions of productivity are equivalent in evaluating the effects of competition and restructuring in electricity generation. However, since the regressions using financial productivity produce a better fit, the author recommends using financial productivity to evaluate the effects of regulation.

INTRODUCTION

With the passage of the Energy Policy Act (EPAct) of 1992, the electric utility industry has moved toward a more competitive wholesale market. This act establishes a new class of exempt wholesale generators (EWGs), which operate independently of state regulation (Barnette, 1998). To enforce this act, the Federal Energy Regulatory Commission (FERC) issued Orders 888 and 889 (FERC 888, 1996 and FERC 889, 1996) in April 1996. Order 888 requires all public utilities to provide open access to their transmission facilities, and Order 889 establishes a code of conduct that requires the utilities to separate their wholesale merchant and transmission functions. While these rules do not mandate industry restructuring, EIA (2000, p. x) reports that, due to state regulation or business strategy, Investor Owned Utilities (IOUs) have collectively either sold to Non-utility Generators (NUGs) or transferred to unregulated affiliates twenty-two percent of their generating capacity during the period 1997 through 2000. As a result NUG net generation increased from nine percent of the market in 1992 to eleven percent in 1998. While these developments certainly introduced competition in the generation of electricity, the degree of competition varied among the states.

Regulators hope that increased competition will improve efficiency and lead to lower rates. If these goals are to be achieved, one would expect a positive correlation between productivity improvements and changes in the competitive environment, *ceteris paribus*. Scully (1998) did examine restructuring in New Zealand and found significant improvement in productivity subsequent to the restructuring, but most of the improvement was the result of changes in labor laws and mergers of adjacent distribution companies. Barnette et. al. (2004) did find modest improvement in total factor productivity in the year that NUG competition increases, but the improvement did not continue in the following year.

The Federal Energy Regulatory Commission (FERC) maintains a data base of financial reports prepared by investor-owned utilities (IOUs) since 1994, but beginning in 2002 FERC no longer requires firms to report the number of employees. Consequently, any traditional analysis of the effects of deregulation on productivity is limited to the period 1994 through 2001. Since EPAct was still being implemented during much of this period, such analysis will be limited to short-term effects on productivity during the transition period. (Barnette et. al. (2004) used these reports.)

Blocher, Stout, & Cokins (2010) defines two measures of productivity—operational productivity and financial productivity. Operational productivity is defined as output per physical unit of input, and financial productivity is output per monetary unit of input. When measuring Total Factor Productivity (TFP), economists typically use physical units to measure labor (employees or labor hours) and energy. As stated above, this measure makes it more difficult to measure productivity changes as a result of changes in regulation since 2001.

The purpose of this paper is to use both operational productivity and financial productivity to measure the effect of regulation and wholesale competition on the efficiency of Investor Owned Utilities (IOUs). This paper first measures the TFP (operational productivity) of ninety-six electric utilities during the period 1994 to 2001. It then uses two measures of financial productivity with the same firms during 1994 to 2001. By comparing regressions with operational productivity as the dependent variable with those using financial productivity as the dependent variable, one should determine whether financial productivity is a good proxy for operational productivity when physical units are unavailable. If these two measures provide comparable policy conclusions, then one could use the FERC-1 Reports to measure financial productivity for years subsequent to 2001 and use the results to evaluate policy changes since 2001.

TOTAL FACTOR PRODUCTIVITY

Norsworthy and Jang (1992) define the level of total factor productivity as

$$TFP = \frac{\sum_j w_j y_j}{\sum_i v_i x_i} \qquad [1]$$

where y_j is the physical quantity of output j, x_i is the physical quantity of input i, w_j is the share of output j in total revenue, and v_i is the share of input i in the total cost, where

$$w_j = \frac{q_j y_j}{\sum_j q_j y_j} \qquad [2]$$

and

$$v_i = \frac{p_i x_i}{\sum_i p_i x_i} \qquad [3]$$

so that q_j is the price for output j and p_i is the unit cost of input i.

The data for calculating TFP is taken from the Federal Energy Regulatory Commission (FERC) Form No. 1, Annual Report of Major Electric Utilities (FERC-1 Report). This report includes financial statements and detailed schedules of assets, revenues, and expenses. The following discussion gives the FERC-1 schedules from which we derive the output and input measures. The page numbers for these schedules are given in parentheses.

This study calculates TFP with three different sets of inputs. The three different input sets are Operational Productivity (physical units), Financial Productivity (current dollars) and a modified Financial Productivity (1994 dollars). All TFP calculations use mWh of electricity sold (both for resale and to final user) as the single output for a utility. Electric Energy Account (400) gives both the units and total dollars of sales. Since this paper recognizes only one output, [1] reduces to

$$TFP = \sum_i v_i \frac{y}{x_i} \tag{1a}$$

This paper recognizes six inputs: (1) owned capital, (2) leased capital, (3) electricity purchased from others, (4) fuel used in generation, (5) labor, and (6) purchased goods and services. We obtain the physical measures and cost of these inputs from the following FERC-1 schedules.

(1) Owned Capital. For calculating Operational Productivity and 1994 Dollar Financial Productivity, this paper estimates the value of Property, Plant, and Equipment (PPE) at 1994 prices as a proxy for capital input. This allows the capital measure to accommodate differences in vintage, technology, and types of equipment. I start with the beginning balance of plant and equipment in1994 Electric Plant in Service (204-207). To calculate the value for subsequent years at 1994 prices, this model uses Additions, Retirements, Adjustments, and Transfers in this schedule and Depreciation Expense and Adjustments in the schedule Accumulated Provision for Depreciation of Electric Utility Plant (219). To calculate change in capital stock, I add Additions (adjusted to 1994 prices) and subtract depreciation expense, retirements (net of depreciation adjustments), and transfers at current prices. For calculating Financial Productivity, this paper uses the end of year balance of fixed assets in Electric Plant in Service (204-207).

For the capital input weight, this paper follows Jorgenson and Yun (1991) and defines the rental cost of capital as property tax, plus depreciation expense, plus the opportunity cost of capital.[1] Property tax is given in the schedule of Taxes Accrued, Prepaid, and Charged During the Year (262-263). I use Accumulated Provision for Depreciation of Electric Utility Plant and Equipment (219) for depreciation expense. This paper uses financial accounting principles to estimate Weighted Average Cost of Capital (WACC). From the Statement of Income (114-117a), we obtain interest expense and net income before income taxes for the utility. From the Balance Sheet (110-113), I add current notes payable to total long-term debt to obtain total interest bearing debt. The interest cost of capital is

$$\text{Rate} = \frac{\text{Interest Expense}}{(\text{Begin Debt} + \text{End Debt})/2}$$

and the equity cost of capital is

[1] Jorgenson and Yun (1991) also adjust for investment tax credits and tax benefits from depreciation in the US income tax laws. This paper ignores investment tax credits, because they did not apply to the periods of our study. Determining the tax benefits from depreciation would require more data than provided in the FERC-1 reports.

$$\text{ROE} = \frac{\text{EBIT}}{(\text{Begin Equity} + \text{End Equity})/2}$$

where ROE is Return on Equity and EBIT is earnings before income taxes. The WACC is the weighted average of the Interest Rate and ROE (weighted by average debt and average equity).[2] The opportunity cost of capital is the WACC times the Net Utility Plant on the Summary of Utility Plant and Accumulated Provisions for Depreciation (200-201). The user cost of capital is the sum of opportunity cost of capital, depreciation expense, and property taxes.

(2) Leased Capital appears as an expense on the Electric Operation and Maintenance Expense (320-323) schedule. For both Operational Productivity and 1994 Dollar Financial Productivity this paper converts the expense to 1994 dollars as a proxy for physical units (operational productivity). It uses current dollars to assign the TFP weight ($p_i x_i$ in Equation 3). The current dollar Financial Productivity calculation does not convert to 1994 dollars.

(3) Purchased Power appears in mWh in the Electric Energy Account (401a) schedule. The cost appears on the Electric Operation and Maintenance Expense (320-323) schedule. Operational Productivity calculations use mWh as the input. 1994 Dollar Financial Productivity converts the cost of power purchased to 1994 dollars. Current dollar Financial Productivity does not convert to a base price. The current dollar cost of power purchased is used for assigning a weight to this input.

(4) Fuel Used. Ideally, one should use a common physical measure such as BTU to calculate Operational Productivity, but FERC-1 does not consistently give this information in useable form. Therefore, this paper uses the dollar cost on Electric Operation and Maintenance Expense (320-323). It converts to 1994 dollars as the input for both Operational Productivity and 1994 Financial Productivity. It uses current dollar prices for calculating the TFP weight.

(5) Labor. For labor productivity, this paper defines one full time employee equivalent (FTE) used in operation and maintenance (O&M) as a unit of labor for calculating Operational Productivity. FERC-1 (p. 323) lists the number of full time and part time of electric department employees. To calculate FTEs, we assume that a part time employee is the equivalent of one half of a full time employee. Total payroll cost is the sum of operation and maintenance payroll (Distribution of Salaries and Wages, pp. 354-355), employee benefits cost (Electric Operation and Maintenance Expense pp. 320-323), and payroll taxes (Taxes Accrued, Prepaid, and Charged During the Year, pp. 262-263). For calculating input using 1994 Dollar Financial Productivity, this paper adjusts the total payroll cost to 1994 wages.

(6) Purchased Goods and Services. To calculate the cost of purchased goods and services, I take total Operation and Maintenance Expense (Electric Operation and Maintenance Expense pp. 320-323) minus the sum of the cost of rental capital, purchased power, fuel, and labor calculated above. For both Operational Productivity and 1994 Dollar Financial Productivity, this paper converts this cost to 1994 dollars.

[2] Using accounting statements to calculate WACC differs from Jorgenson and Yun (1991). This model calculates interest rates based on the interest rates on outstanding debt, and it uses ROE as a proxy for the equity cost of capital. Jorgenson and Yun (1991) use market rates to determine debt and equity costs of capital.

The above discussion makes frequent references to 1994 dollars. To convert to 1994 dollars, this paper uses three price indices maintained by the U. S. Bureau of Labor Statistics. To convert capital purchases and capital rentals, I use the Turbine and Power Equipment price index. For fuel cost and purchased power, I use the Fuels and Related Products and Power price index. For labor costs, I use the Electric Utility Unit Labor Cost index. For other costs, we use the Electric Power Distribution price index. All of these indices are units of the Producer Price Index.

In the regression model developed in the next section, this paper is interested in measures of absolute TFP and changes in TFP. To calculate changes in TFP, we follow equation [1] and define the change in TFP during year *t* as

$$\Delta TFP = \sum_i v_{i,t} \left(\ln \frac{y}{x_i, t} - \ln \frac{y}{x_{i,t-1}} \right) \qquad [4]$$

where $v_{i,t}$ is the input weight assigned using costs in year *t*, and $\ln \frac{y}{x_i, t}$ is the natural logarithm of the productivity of input *i* in year *t*. The term $\left(\ln \frac{y}{x_i, t} - \ln \frac{y}{x_{i,t-1}} \right)$ is the growth rate of the single factor productivity of input *i* in year *t*.

Regression Models

Barnette et. al. (2004) develops a model to show the relationship between NUG competition and utility restructuring to Total Factor Productivity. It defines the relationship as

$$\begin{aligned} \Delta TFP &= a + b_1 t + b_2 \Delta NUG + b_3 \Delta NUG_{t-1} + b_4 TFP_{t-2} \\ &+ b_5 \Delta TFP_{t-1} + b_6 Divest_1 + b_7 Divest_2 + \varepsilon \end{aligned} \qquad [5]$$

where *a* is the intercept, the *b*'s are coefficients, and ε is the error. *t* is a number for the year, where 1996 is year 1 and 2001 is year 6. ΔNUG is the difference in the logarithms of the non-utility market shares from the previous year to the current year. TFP_{t-2} is the absolute productivity for two years prior to the current year. ΔTFP_{t-1} is the change in total Total Factor Productivity in the previous year. $Divest_1$ and $Divest_2$ are two dummy variables to indicate whether a firm has been forced by regulators to sell a significant portion of its generation assets. During the first year of divestiture, $Divest_1$ assumes a value of 1, and during subsequent years $Divest_2$ assumes a value of 1. ($Divest_1$ reverts to 0.) These dummy variables reflect the fact that during divestiture, the utility is in effect substituting purchased power for generation capital, fuel, and labor. While input substitution for business reasons may be common, forced divestiture may not necessarily have the same effect on productivity. I obtain NUG market shares from the Energy Information Administration (EIA) web site. To obtain values for the divestiture dummies, I rely on the notes to the financial statements included in the FERC-1 reports.

This paper repeats the regression six times, twice for each measure of productivity: Operational Productivity, 1994 Dollar Financial Productivity, and Current Dollar Financial Productivity. For the first regression for each productivity measure, I define NUG as the percentage of total capacity in a state that is owned by a non-utility generator. For the second series of regressions, I define NUG as the percentage of total generation provided by non-utility generators.

REGRESSION RESULTS

Table 1 (below) shows the regression results for the three measures of productivity where the NUG variable is defined as the non-utility share of total generation capacity in a state. For all regressions the Time coefficient is not significant at the 90%-level. For the two measures of financial productivity, the coefficient for Δ LN NUG (t-1) is significant at the 90%-level; all other coefficients are significant at the 95%-level of confidence. All coefficients, other than time, have the same sign in each regression. In other words the sign for Δ LN NUG is the same across all three regressions. The same is true for other coefficients. All coefficients except time are significant at the 95%-level when operational productivity is the independent variable.

Table 1: REGRESSION RESULTS WITH NUG CAPACITY

	Operational Productivity		**1994 Dollar Financial Productivity**		**Current Dollar Financial Productivity**	
Independent Variable	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
Intercept	-0.05201	-1.40205	-0.059938	-1.49969	-0.08203*	-1.98090
Time	-0.00018	-0.02842	0.005043	0.87783	0.00775	1.33404
Δ LN NUG	-0.04287*	-2.67275	-0.029813*	-2.06097	-0.03172*	-2.19849
Δ LN NUG (t-1)	0.04079*	2.88215	0.023931**	1.86600	0.02366**	1.84911
TFP (t-1)	0.00024*	4.83800	10.176529*	14.89663	10.81020*	14.05411
Δ TFP (t-2)	-0.00015*	-2.60266	-9.665016*	-12.71375	-10.10121*	-12.32041
Divest 1	0.25692*	4.50054	0.244347*	4.71243	0.24095*	4.66572
Divest 2	0.49709*	8.31272	0.494491*	9.05940	0.50087*	9.21644
R-Square	0.19448		0.39989		0.37685	
Adj. R-Square	0.18456		0.39250		0.36917	
*Significant at the 95% level, **Significant at the 90% level						

The purpose of this paper is to determine the extent to which operational productivity is equivalent to financial productivity when analyzing the effect of policy or exogenous variables on Total Factor Productivity. Table 2 (below) shows the 90% confidence intervals for the four exogenous variables under each definition of the independent variable. The coefficients for these measures for each definition of productivity (Table 1) are within the 90% confidence intervals for the other two measures. When this observation is combined with the fact that all coefficients have the same sign when compared to the other productivity definition, one can conclude that for the purpose of evaluating policy alternatives all three methods of measuring productivity yield equivalent results.

Table 2: 90% CONFIDENCE INTERVALS FOR EXOGENOUS VARIABLES WITH NUG CAPACITY

	Operational Productivity		1994 Dollar Financial Productivity		Current Dollar Financial Productivity	
Independent Variable	**Lower 90%**	**Upper 90%**	**Lower 90%**	**Upper 90%**	**Lower 90%**	**Upper 90%**
Δ LN NUG	-0.06929	-0.01644	-0.053646	-0.00598	-0.05550	-0.00795
Δ LN NUG (t-1)	0.01747	0.06410	0.002802	0.04506	0.00258	0.04474
Divest 1	0.16287	0.35098	0.158920	0.32978	0.15587	0.32603
Divest 2	0.39857	0.59561	0.404563	0.58442	0.41133	0.59040

Tables 3 and 4 (below) show the coefficients, t-statistics, and 90% confidence intervals for the regressions when the NUG variable is defined as the change in the non-utility generators' share of output in the state in which the utility is operating. The results are similar to those obtained when the NUG variable is based on capacity, but for both regressions of financial productivity the coefficients related to changes in the NUG share of the market are not significant at the 90% level of confidence. The coefficients for the exogenous variables all fit within the 90% confidence intervals of the other regressions.

Table 3: REGRESSION RESULTS WITH NUG GENERATION

	Operational Productivity		1994 Dollar Financial Productivity		Current Dollar Financial Productivity	
Independent Variable	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
Intercept	-0.05304	-1.42706	-0.058764	-1.46361	-0.08093**	-1.94518
Time	-0.00076	-0.11783	0.005131	0.88784	0.00776	1.32678
Δ LN NUG	-0.02928*	-2.11573	-0.019155	-1.53645	-0.02038	-1.63754
Δ LN NUG (t-1)	0.03345*	2.47863	0.014889	1.21512	0.01469	1.20164
TFP (t-1)	0.00024*	4.87398	10.206336*	14.87194	10.83085*	14.01139
TFP (t-2)	-0.00015*	-2.62455	-9.727108*	-12.75808	-10.15201*	-12.33529
Divest 1	0.24983*	4.38058	0.238329*	4.60152	0.23463*	4.54680
Divest 2	0.49913*	8.33707	0.496975*	9.08968	0.50329	9.24362
R-Square	0.18984		0.39623		0.36507	
Adj. R-Square	0.17986		0.38878		0.21928	
*Significant at the 95% level, **Significant at the 90% level						

Table 4: 90% CONFIDENCE INTERVALS FOR EXOGENOUS VARIABLES WITH NUG GENERATION

	Operational Productivity		**1994 Dollar Financial Productivity**		**Current Dollar Financial Productivity**	
Independent Variable	**Lower 90.0%**	**Upper 90.0%**	**Lower 90.0%**	**Upper 90.0%**	**Lower 90.0%**	**Upper 90.0%**
Δ LN NUG	-0.05209	-0.00648	-0.039695	0.00139	-0.04088	0.00012
Δ LN NUG (t-1)	0.01121	0.05568	-0.005299	0.03508	-0.00545	0.03484
Divest 1	0.15587	0.34379	0.152997	0.32366	0.14961	0.31965
Divest 2	0.40049	0.59776	0.406896	0.58705	0.41359	0.59300

CONCLUSION

This paper provides some support to the hypothesis that when one is examining the impact of a policy on changes in Total Factor Productivity it makes little difference whether one defines input in terms of physical units or monetary costs. Whether one defines the NUG share of the market in terms of capacity or generation, the coefficients on the exogenous variables have the same sign regardless of how we measure productivity. Likewise, the values of the coefficients in the regression for one measure of productivity fall within the 90% confidence interval of the same coefficient with another measure. However, the fact that the values of the coefficients of the NUG variables are not significant when the NUG share is defined in terms of output raises the question whether we can universally accept operational productivity as equivalent to financial productivity.

There is a major difference between the Adjusted R-Square for operational productivity and financial productivity. This could be due to the difficulty in developing physical measures of fuel input and capital input. For future studies, it may be useful to calculate the productivity at the divisional level—generation, transmission, and distribution. Doing so will make it possible to come up with a common measure of capital for each division. Also, determining an opportunity cost for internally generated electricity would make it possible to calculate the benefits of increasing reliance on purchased power.

While this study does not show clear evidence that the change in operational productivity is equivalent to the change in financial productivity, the author suggests that future studies could safely use one of the two measures of financial productivity. For one, the Adjusted R-Squares for the regressions for financial productivity are much stronger. This suggests a better fit. More importantly is the purpose of encouraging competition in generation is to reduce the costs of producing electricity. This purpose can be achieve both by the utility becoming more efficient in using its resources and by being more diligent in obtaining a better price for its inputs. Financial productivity will capture both effects, but operational productivity will not.

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