ARE U.S. COAL-FIRED POWER PLANTS QUANTITY-QUALITY EFFICIENT?

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Overview

The competitiveness of electricity generation by coal-fired plants is affected by the fuel supplied, operating heat rate or heat content of the coal along with ash and sulfur emissions, rate of innovations/adoption and to a large extent the quantity-quality production efficiency of power plants. Operating heat rate, the amount of electricity produced per btu of fuel has been decreasing for coal, in part due to the loss of efficiency caused by the installation of scrubbers which have been installed to meet environmental regulatory requirements. The use of emissions-reducing technology has been increasing since the passage of the Clean Air Act in 1970. The environmental benefits of these emissions-reducing technologies comes with a cost. There is a loss of efficiency as they require electricity to operate. The resulting parasitic load, electricity used internally by the power plant, is no longer available to customers. The parasitic load of scrubbers is typically two percent of output (Bellas and Lange 2008). Although coal is a relatively low-cost fuel, new regulations including mercury, sulfur, NOx, have increased the cost of coal-fired electricity. Nearly 13 GW of coal-fired generation are expected to be retired in 2015, eight GW of that in Indiana, Kentucky, Ohio, West Virginia, and Virginia. These plants are smaller, averaging 158 MW, than the average for the remainder of the fleet, 261 MW. These units had a weighted-average capacity factor of 24 percent in 2013, compared to an industry average of 60 percent. Among the motivating factors for these retirements is the implementation of the Environmental Protection Agency's Mercury and Air Toxic Standards (MATS) rule. MATS enforces stricter emissions standards for large coal- and oil-fired plants. While on June 30, 2015, the Supreme Court ruled against the EPA for not properly considering the cost of compliance for utilities, the rule was not struck down.

The goal of this research is to provide information to state and federal policy makers and regulator, consumers, industry, and environmental advocates on the competitiveness of electricity generation by the U.S. coal energy industry. As a first step towards understanding the implications of changes in coal-fired power plants generating electricity, this study investigates the inclusion of quantity-quality variables including environmentally sensitive variables like ash, sulfur andheat content of coal on technical efficiency of coal-fired power plants generating electricity in the U.S. Second, is there a difference in coal-fired power plants efficiency across states? This research is accomplished by a random effects panel stochastic frontier analysis to estimate technical efficiency patterns using plant level information from 2008 to 2013 based on primal production function. A subsidiary objective is to look at the changes in the technical efficiency patterns across plants within North Dakota generating electricity using coal for the same time period.

North Dakota was picked as a very interesting state given much increased oil and natural gas production recently due to the development and adoption of fracking technologies in this subsector. In addition, North Dakota is a major electricity exporting state and has signifficant coal reserves. The vitality of North Dakota's coal power industry is relatively large. So, continued increasing regulation results in plant closures which would have a disproportionate impact on the state economy. Hence it is interesting to see the performance of the coal sector in North Dakota during this diversification and regulation period in the local energy sector.

Methods

Unlike the traditional primal production function that used quantity of inputs, this research differentiates the inputs into quantity variables x and quality variables z. The quantity variables includes the main ingredient, coal fuel used telectricity by the boiler plants. Production theory suggests, the higher use of the traditional quantity inputs should lead to higher output. In contrast the quality variables include heat content, suur and ash content. To address, the environmental aspects of sulfur and ash, the inverse of the two variables were used in the analysis. As positive sign of these variables indicates sulfur and ash negatively impact electricity generation by coal-fired plants.

The primal production function with traditional quantity and quality inputs can be estimated using stochastic frontier analysis (SFA) that decomposes the traditional error ε into a symmetrical random error v and a one-sided error or infficiency u. In this research, following Greene (2005), the true random effect (tre) panel stochastic frontier is used and estimated.

All the variables, inputs and output are in logarithms, so the parameter coefficients are elasticities. It is to be noted, the quality variables - sulfur and ash are measured as the logarithm of one over inverses of their percent by weight in the model. The magnitude of the parameter coe_cient of sulfur and ash is the same, but the sign is the opposite.

Results

There is a positive and statistically significant relationship between fuel and the amount of coal-fired plants generating electricity. A one percent increase in fuel used by the power plant will increase electricity generation by 0.869 percent. The square of fuel is positive and statistically significant suggesting the use of fuel is increasing at an increasing rate of 0.021 percent to produce electricity. The quality of the fuel in the terms of the heat content is also positive and signicant. However, a one percent increase in the heat content will increase electricity generation by 3.309 percent. In contrast the square of heat content is negative and signifficant suggesting increasing at a decreasing rate by 0.569 percent. Positive relationships between the sulfur and ash coefficients are as expected as these are introduced as inverses. A one percent increase in sulfur and ash will decrease electricity generation by 0.322 percent and 2.735 percent, respectively. This suggests, compared to sulfur, ash has higher negative effect on electricity generation. So a slightly lower content of ash will lead to higher production of electricity. The square term of sulfur and ash is positive and statistically signifficant suggesting decreasing at a decreasing rate of 0.079 and 0.117 percent, respectively.

The technology of coal-fired plants represented by the trend coefficient has a negative sign meaning that on average plants are becoming less efficient. This is not surprising given the industry's declining average operating heat rate which is occurring in part because of the use of scrubbers. In addition, the square term of trend is negative and signifficant suggesting the technology is decreasing at a decreasing rate. This could be attributed to lower investment in developing technologies in coal industry due to negative stereotype or pessimism about the long-term viability of coal power in the face of increasing regulation. This need to be conveyed to the policy maker and more so the coal industry.

With respect to the interaction terms of the translog production function, all the variables are statistically signifficant with the exception of fuel-sulfur and heat-trend interaction. All the interaction terms are negative and statistically signifficant. This suggests the interaction terms are increasing (decreasing) at a decreasing rate if the individual variables are positive (negative). The interaction of fuel with technology represented by trend is positive suggesting technology associated with extraction or providing fuel was positive. In addition, the technology associated with sulfur and ash content of the fuel has been on the rise as these variables are represented as inverses.

Plant efficiency varies greatly across the country. This is best seen by looking at the maximum and minimum efficiency for each state. Kentucky and Michigan had among the least efficient plants while Minnesota, New York, and Wisconsin have among the most efficient. North Dakota's coal-fired power plants are in the middle range of efficiency and are consistent. The efficiency of each plant in North Dakota is near the national industry average. There are only small uctuations in efficiency across the period, with no sign of a trend.

Conclusions

In this study the relative e_ciency of U.S. coal power plants was estimated using data from EIA survey 923. Stochastic frontier analysis proved a suitable method to estimate the relative efficiency of individual coal-fired plants generating electricity. This study using quantity-quality inputs to estimate a translog production function. The parameter coefficient of primary, square and interaction terms of the translog production function of coal-fired plants provided consistent sign and estimates. In addition, the technology defined by time trend also provided consistent estimates for the coal-industry. Estimation of a negative time trend coefficient may be explained by the use of scrubbers which allow plants to meet emissions standards, but decrease efficiency. The analysis finds that North Dakota coal-fired power plants have efficiency near the national average and are relatively consistent performers over time. This result is of importance to policy makers and more importantly to coal industry.

References

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