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An Economic and Statistical Analysis of the "War on Coal."

Introduction

The coal industry in the United States has been hit by a "perfect storm" in recent years. Several factors have contributed to the decline in the coal industry: heightened competition with natural gas in electric power generation, environmental regulations affecting coal – fired power plants, federal and state government subsidies for the development of wind and solar power generation capacity and weakening export markets for U.S. coal.

This report focuses on the demand for coal for electric power generation, the principal market for U.S. coal. In 2015, the electric power sector accounted for 92 percent of the domestic market for coal and around 85 percent of the total market for U.S. coal (Appendix Table A1). After hovering in the 48 - 52 percent range during 200 -2008, coal's share of fuels used for electricity generation has fallen precipitously in recent years, to 33.2 percent in 2015 and a forecast 29.9 percent in 2016 (Appendix Table A2).

As noted above, government policies affecting coal are the environmental regulations already implemented by the Environmental Protection Agency (EPA) and those proposed for future implementation and subsidies for renewable sources of energy, primarily wind and solar. The EPA regulations have been characterized by the coal industry and its supporters as a "war on coal." Others argue that the recent decline in coal use for electric power generation is primarily market-driven, namely the increased use of natural gas at the expense of coal.

The particular interest of this study is to investigate these opposing views in an objective manner. The statistical model developed for this study allows one to separate the government policy effects from the market effects. The model provides a quantitative assessment of the effects of government policies on the consumption of coal for electric power generation and, by extension, the effects of those policies on coal mining employment. The government policy variable incorporated into the study measures the combined effect of EPA regulations and government subsidies for wind and solar.

Background

Overview

Analysts in the Energy Information Administration (EIA) of the U.S. Department of Energy presented an excellent summary of the recent situation and the short-term outlook for coal use in electric power generation in the March 16, 2016, online issue of "Today in Energy." The full report is available at http://www.eia.gov/todayinenergy/detail.cfm?id=25392.

For decades, coal has been the dominant energy source for generating electricity in the United States. EIA's Short-Term Energy Outlook (STEO) is now forecasting that 2016 will be the first year that natural gas-fired generation exceeds coal generation in the United States on an annual basis. Natural gas generation first surpassed coal generation on a monthly basis in April 2015, and the generation shares for coal and natural gas were nearly identical in 2015, each providing about one-third of all electricity generation.

The mix of fuels used for electricity generation has evolved over time. The recent decline in the generation share of coal, and the concurrent rise in the share of natural gas, was mainly a market-driven response to lower natural gas prices that have made natural gas generation more economically attractive. Between 2000 and 2008, coal was significantly less expensive than natural gas, and coal supplied about 50% of total U.S. generation. However, beginning in 2009, the gap between coal and natural gas prices narrowed, as large amounts of natural gas produced from shale formations changed the balance between supply and demand in U.S. natural gas markets.

Environmental regulations affecting power plants have played a secondary role in driving coal's declining generation share over the past decade, although plant owners in some states have made investments to shift generation toward natural gas at least partly for environmental reasons. Looking forward, environmental regulations may play a larger role in conjunction with market forces. Owners of some coal plants will face decisions to either retire units or reduce their utilization rate to comply with requirements to reduce carbon dioxide emissions from existing fossil fuel-fired power plants under the Clean Power Plan, which is scheduled to take effect in 2022 but has recently been stayed by the Supreme Court pending the outcome of ongoing litigation.

Beyond the growing market share for natural gas-fired generation over the past decade, coal's generation share has also been reduced by the growing market share of renewables other than hydroelectric power, especially wind and solar. Unlike the growth of natural gas-fired generation, which has largely been market-driven, increased use of nonhydro renewables has largely been driven by a combination of state and federal policies. The use of renewable energy sources such as wind and solar has also grown rapidly in recent years so that generation from these types of renewables is now surpassing generation from hydropower.

Coal-Fired Generation Capacity Retirements

According to the EIA, nearly 18 gigawatts (GW) of electric generating capacity was retired in 2015, a relatively high amount compared with recent years. Around 80 percent of the retired capacity was conventional steam coal, around 14 GW … one gigawatt = 1,000,000 kilowatts.

The amount of coal-fired generation capacity retired in 2015 was about 4.6 percent of the nation's coal capacity at the beginning of that year. Nearly half of the 2015 retired coal capacity was located in three states—Ohio, Georgia, and Kentucky—and those states each retired at least 10 percent of their coal capacity. Other states that traditionally have had high levels of coal-fired electricity generation, such as Indiana, West Virginia, and Virginia, each retired at least one GW of coal capacity in 2015.

The EIA reported that 30 percent of the coal capacity that retired in 2015 occurred in April, which is when the U.S. Environmental Protection Agency's Mercury and Air Toxics Standards (MATS) rule went into effect. Some coal plants applied for and received one-year extensions, meaning that many of the coal retirements expected in 2016 likely occurred in April. Several plants have received additional one-year extensions beyond April 2016 based on their role in ensuring regional system reliability.(For additional information on 2015 coal plant retirements, see the March 8, 2016, online issue of "Today in Energy" at http://www.eia.gov/todayinenergy/detail.cfm?id=25272.)

Latest data show that an additional 4.1 GW of coal-fired generation capacity was retired in the first quarter of 2016. The final deadline for compliance with the EPA's Mercury and Air Toxics Standards (MATS) was April 2016. Consequently, coal plant retirements in 2016 are likely to be record high, 40 – 45 GW, according to EIA. (See "Annual Energy Outlook 2016 Early Release: Annotated Summary of Two Cases," EIA, May 17, 2016, p.27. The full report is available at http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2016).pdf.)

If the EIA forecast for coal plant retirements in 2016 materializes, the amount of coal-fired generation capacity retired this year will easily exceed the total retired during the previous decade. Clearly, coal plant retirements in 2015 and 2016 are motivated by the costs of complying with MATS. Nevertheless, while there is a significant drawdown in capacity, there is room for sizeable expansion in coal-fired electricity generation should the need arise. Coal plants are operating at historically low rates of capacity utilization. The EIA reported capacity utilization by coal plants at 54.6 percent in 2015. Capacity utilization in first quarter 2016 averaged 46.3 percent, down from 59.3 percent a year earlier. The unprecedented low rate of capacity utilization in first quarter 2016 was occasioned by a rise in the ratio of coal cost to natural gas cost, from 0.56 in first quarter 2015 to 0.80 in first quarter 2016.

The Statistical Model

The demand for coal for electric power generation is derived from the demand for total generation. Total generation is affected by economic growth and weather patterns. Other things equal, one expects coal use to increase when total generation increases and decrease when total generation decreases. Total generation has been remarkably stable in recent years and, thus, has not affected the consumption of coal for electric power generation in a measurable way (Table A2).

Other factors affecting coal consumption for electric power generation are outlined above in the EIA report. The key assumption for the statistical model developed for this report is that changes in coal consumption that are not attributed to coal's competition with natural gas are attributed to EPA regulations and the state and federal subsidies for wind and solar. This is a reasonable assumption given the relative stability in total electricity generation, the remaining variable of any importance. Moreover, inspection of market shares presented in Table A2 shows that nearly all the changes over time are in the shares captured by coal, natural gas and, more recently, wind and solar.

Coal and Natural Gas

Coal and natural gas have been competing in electric power generation for decades. Until recently, coal had a competitive edge. From 2000 through 2008, the annual average ratio of coal cost to natural gas (cost of coal and natural gas delivered to electricity generation plants) ranged from 0.187 to 0.352; from 2009 through 2015, coal lost its competitive edge as the ratio ranged from 0.446 to 0.696 (Table A3).

Simple linear regression equations were estimated to quantify the effect of changes in the cost ratio (CC/CNG) on coal consumption in the electric power sector. The results, using data in Table A3, are reported in Table 1, along with explanatory footnotes. The initial equation (A15 in Table 1) was estimated using annual data for 1995 through 2015. The results indicate that changes in the cost ratio alone accounted for 84.1 percent of the annual variation in coal consumption over the period. However, the equation performed poorly in predicting coal consumption for years 2013 – 2015. For those years, actual consumption was well below that predicted by the statistical model (not shown).

A simple regression equation was then estimated based on annual data covering 1995 – 2012. The result (model A2 in Table 1) was an improvement over model A15 in terms of explanatory power; changes in the cost ratio accounted for 89.5 percent of the annual variation in coal consumption. Clearly, beginning with 2013, factors other than the coal- to -natural gas cost ratio began playing a larger role in determining coal consumption. To test this idea further, an equation (A17) was estimated with EIA forecasts for 2016 and 2017 included along with 1995 – 2015 actual data. The explanatory power declined to 81.9 percent, suggesting an even larger role for the other factors - EPA regulations and subsidies for wind and solar.

Government Policy

The challenge in specifying a statistical model to estimate the effect of government policies on coal consumption for electricity generation is that the effects vary by year and are cumulative. For example, coal plant retirements in 2016 affect coal consumption not only in 2016, but in following years as well. The statistical model developed for this study directly measures the cumulative effect of government policies on coal consumption for electric power generation.

Statistical results and explanatory notes are shown in Table 1. Equation B15 was estimated using final data for years 1995 – 2015. Equation B17 was estimated using data for years 1995 – 2017; years 2016 and 2017 are forecasts by EIA as of June 2016 (Table A3). The estimated cumulative policy effects begin with year 2013 - recall that the model based solely on the CC/CNG variable performed poorly beginning with 2013. It should be pointed out that the coefficient on G13 includes the cumulative effect on coal consumption of government policies for years prior to 2013, estimated at a modest - 20.04 million short tons.

The estimated coefficients for the government policy variable are interpreted as follows, using G15 as an example. The G15 coefficient indicates that the quantity of coal consumed for electric power generation in 2015 was 105.27 million short tons smaller than it would have been without the EPA regulations affecting coal and the federal and state government subsidies for wind and solar power.

Implications for Coal Mining Employment

The demand curve for coal for electric power generation has declined each year since 2012 due to the negative impacts of EPA regulations and government policies to encourage development of renewable sources of energy. These leftward-shifting demand curves for coal are shown in Figure A1. The horizontal distance (in million short tons) between each demand curve and the demand curve for 2012 is the cumulative effect of EPA regulations and government policies on coal consumption. These cumulative effects are the coefficients for variables G13 through G17; for example, the cumulative shift from 2012 to 2015 is – 105.27 million short tons (Table 1).

The reduction in the quantity of coal consumed for electric power generation ultimately translates into less coal production and fewer coal mining jobs. The amount of coal displaced by EPE regulations and government subsidies for renewals is an estimated 105.27 million short tons through 2015. It would take 9,269 coal miners working fulltime to produce that amount of coal, based on average productivity (tons per labor hour). The forecasts for 2016 and 2017 are that coal displaced by EPA regulations and government policies will increase to cumulative totals of 141.2 and 179.59 million short tons, respectively. These quantities are the equivalent of 12,433 U.S. coal mining jobs through 2016 and 15,900 jobs through 2017 (Table 2).

Table 1. Statistical Results.					
	Statistical Model				
	A15[1]	A12[2]	A17[3]	B15[1]	B17[3]
Dependent Variable	QCEP[4]	QCEP[4]	QCEP[4]	QCEP[4]	QCEP[4]
	Estimated Coefficients				
Intercept	1,131.98	1,111.64	1,160.92	1,111.64	1,111.64
CC / CNG[5]	-460.23	-385.06	-551.25	-385.06	-385.06
G13[6]				-45.55	-45.55
G14[6]				-77.57	-77.57
G15[6]				-105.27	-105.27
G16[6]					-141.20
G17[6]					-179.59
R-Squared, adj.[7]	0.841	0.895	0.819	0.932	0.961

[1] Years 1995 – 2015 are included. [2] Years 1995-2012 are included. [3] Years 1995-2017 are included. [4] Quantity of coal consumed for electric power generation, million short tons. [5]Ratio of coal cost to natural gas cost. [6] O – 1 variables to estimate the cumulative effects on QCEP of environmental regulations and subsidies for renewable energy sources. [7]The proportion of the annual variation in QCEP that is explained by the statistical model. Note: All estimated coefficients (all models) are statistically significant at the 97 percent confidence level or greater.

Table 2. Full Time Job Equivalents (FTE) of Coal Displaced by Environmental Regulations and Subsidies for Renewable Energy Sources.			
	Coal Displaced	Coal Miner Productivity[1]	Full Time Job Equivalents[2]
Year	Mil. Short Tons Cumulative	Short Tons per Hour Cumulative Average	FTE Cumulative
2013	45.55	5.37	4,078
2014	77.57	5.40	6,906
2015	105.27	5.46	9,269
2016F	141.20	5.46	12,433
2017F	179.59	5.43	15,900

[1] Data for calculations: U.S. Energy Information Administration, *Short-Term Energy Outlook – Coal*, June 2016. The cumulative average for each row is calculated as the simple average of coal miner productivity for each year included in the cumulative total.

[2] Based on 2,080 hours of work per year. The FTE is an estimate of the number of coal miners required to produce the quantity of coal displaced, assuming average productivity. Sample calculation: 2013 FTE = (45.55/5.37) times (1,000,000/2,080) = 4,078.

Clean Power Plan

The forecast horizon for the statistical analysis presented above is through 2017, which is the horizon for EIA's short-term energy outlook (STEO). Looking farther down the road, the key to coal production and use is whether the Clean Power Plan (CPP) promulgated by the EPA is implemented. The CPP, which imposes caps on carbon dioxide emissions from fossil-fueled power plants, is scheduled to take effect in 2022. However, CPP implementation was recently stayed by the U.S. Supreme Court pending judicial review.

This May, the EIA published an analysis of two scenarios – implementation of the CPP versus no CPP. A summary of the report is available at http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2016).pdf.).

If the CPP is not implemented, the U. S. coal industry of 2030 - 2040 would closely resemble today's industry in terms of production and use levels, according to the EIA analysis. However, if the CPP is adopted, coal production and use in 2030 – 2040 would be about two-thirds of current levels. Coal's share of electricity generation, 50 percent a decade ago and around 30 percent currently, would plummet to 21 percent by 2030 and to 18 percent by 2040. Under this scenario, the health of the U.S. coal industry depends increasingly on export markets.

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APPENDIX

Table A1. Coal Production, Imports and Use, 2013 – 2017.					
	2013	2014	2015	2016F	2017F
	Million Short Tons				
Supply:					
Production	948.8	1,000.0	895.4	740.8	768.0
Imports	8.9	11.3	11.3	11.6	10.8
Use:					
Electric Power	858.0	851.6	739.7	667.4	694.1
Exports	117.7	97.3	74.0	66.2	58.1
Other	66.4	66.1	61.9	59.9	59.9
Total Use	1,042.1	1,015.0	875.6	793.5	812.1
	Percent				
Electric Power Use as a Percent of Total Use	82.3	83.9	84.5	84.1	85.5
Data for calculations: U. S. Energy Information Administration, *Short-Term Energy Outlook – Coa*l, June 2016.					

Table A2. Share of U. S. Electricity Generation by Fuel and Trend in Total Generation.							
	Fuel						
	Coal	Natural Gas	Petroleum	Nuclear	Hydropower	Renewables[1]	Other
Year	Percent						
2010	44.8	23.9	0.9	19.6	6.4	4.1	0.5
2011	42.2	24.7	0.7	19.3	7.8	4.7	0.5
2012	37.4	30.3	0.6	19.0	6.8	5.4	0.5
2013	38.8	27.7	0.6	19.4	6.6	6.2	0.7
2014	38.6	27.5	0.7	19.5	6.3	6.8	0.5
2015	33.2	32.7	0.7	19.5	6.1	7.3	0.5
2016F	29.9	34.4	0.6	19.5	6.7	8.3	0.6
2017F	30.9	33.3	0.6	19.2	6.5	8.9	0.6

Index, Total Generation[2]						
2011	2012	2013	2014	2015	2016F	2017F
101.6	100.0	100.7	101.4	101.3	100.7	102.4

[1] Nonhydro renewables - primarily wind and solar. [2] 2012 = 100.

Data for calculations: U.S. Energy Information Administration, *Short-Term Energy Outlook - Electricity*, June 2016 and *Electricity Data Browser – Net Generation*, June 2016.

Table A3. Data for Statistical Analysis.									
Year	Coal Consumption[1]	Coal Cost[2]	NG Cost[2]	Coal Cost/NG Cost	G13	G14	G15	G16	G17
1995	850.2	1.32	1.98	0.667	0	0	0	0	0
1996	896.9	1.29	2.64	0.489	0	0	0	0	0
1997	921.4	1.27	2.76	0.460	0	0	0	0	0
1998	936.6	1.25	2.38	0.525	0	0	0	0	0
1999	940.9	1.22	2.57	0.475	0	0	0	0	0
2000	985.8	1.2	4.33	0.277	0	0	0	0	0
2001	964.4	1.23	4.44	0.277	0	0	0	0	0
2002	977.5	1.25	3.55	0.352	0	0	0	0	0
2003	1005.1	1.28	5.39	0.237	0	0	0	0	0
2004	1016.3	1.36	5.96	0.228	0	0	0	0	0
2005	1037.5	1.54	8.23	0.187	0	0	0	0	0
2006	1026.6	1.69	6.92	0.244	0	0	0	0	0
2007	1045.1	1.77	7.09	0.250	0	0	0	0	0
2008	1040.6	2.07	9.04	0.229	0	0	0	0	0
2009	933.6	2.21	4.73	0.467	0	0	0	0	0
2010	975.1	2.27	5.09	0.446	0	0	0	0	0
2011	932.5	2.39	4.73	0.505	0	0	0	0	0
2012	823.6	2.38	3.42	0.696	0	0	0	0	0
2013	858	2.34	4.33	0.540	1	0	0	0	0
2014	851.6	2.36	4.98	0.474	0	1	0	0	0
2015	739.7	2.23	3.22	0.693	0	0	1	0	0
2016F	667.4	2.18	2.77	0.787	0	0	0	1	0
2017F	694.1	2.20	3.56	0.618	0	0	0	0	1
[1] Coal consumed for electric power generation, million short tons. [2] Costs of coal and natural gas delivered to electricity generation plants, dollars per million BTU. G13 – G17 are 0 - 1 variables to estimate the cumulative effects on coal consumption of environmental regulations and subsidies for renewable energy sources.									
Source for consumption and cost data: U.S. Energy Information Administration*, Short-Term Energy Outlook – STEO Custom Table Builder*, June 2016.									

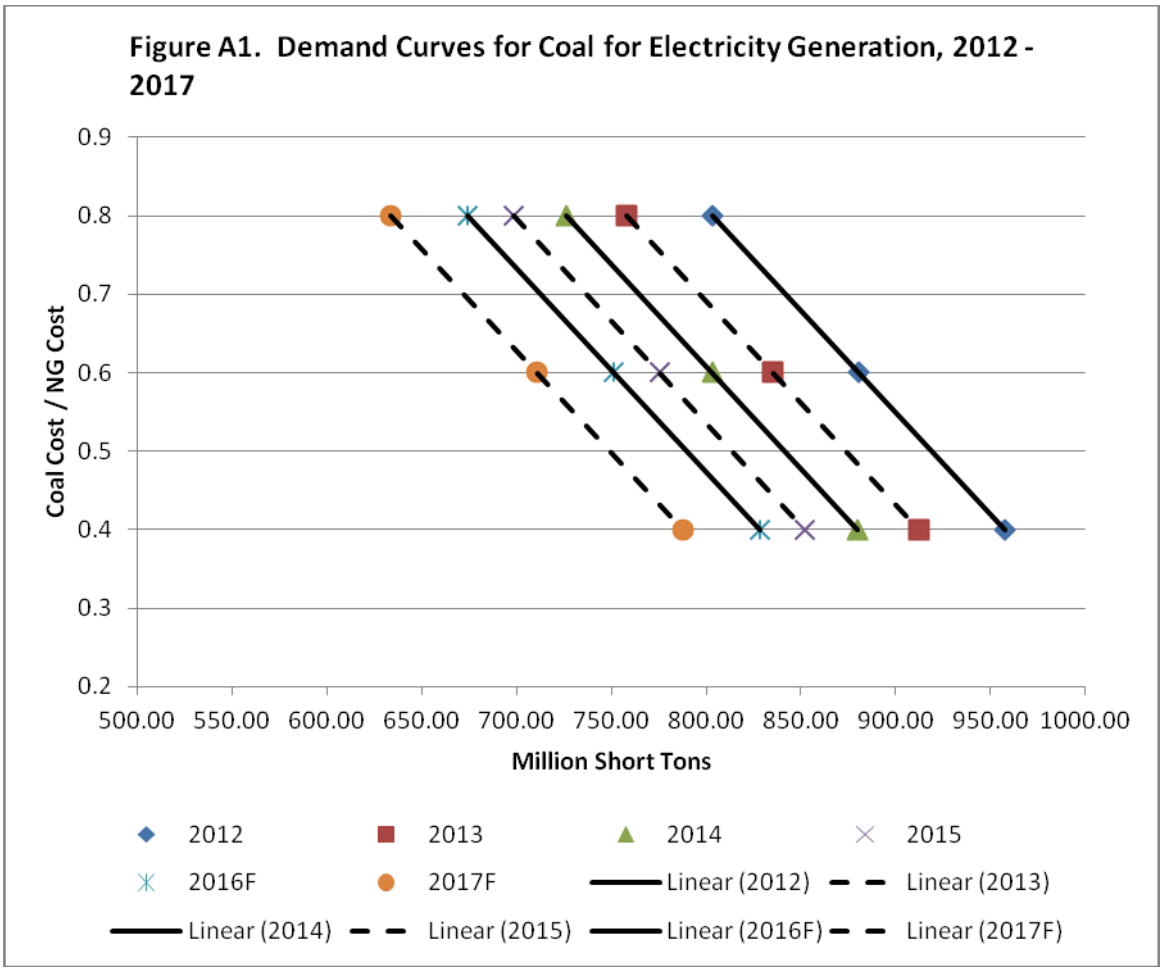
Figure A1. Demand Curves for Coal for Electricity Generation, 2012 - 2017
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Coal Cost / NG Cost
500.00 550.00 600.00 650.00 700.00 750.00 800.00 850.00 900.00 950.00 1000.00
Million Short Tons
2012
2013
2014
2015
2016F
2017F
Linear (2012)
Linear (2013)
Linear (2014)
Linear (2015)
Linear (2016F)
Linear (2017F)