Prolonging Coal's Sunset: The Causes and Consequences of Local Protectionism for a Declining Polluting Industry

Jonathan Eyer

USC

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Matthew E. Kahn

USC and NBER

Abstract

A transition away from coal fired power would improve local air quality and would help the U.S to establish itself as a global leader in the collective effort to mitigate the climate change challenge. The costs of substituting away from coal are spatially concentrated, and mining states are already experiencing lost income due to the reduced demand for coal. We document that power plants in states and counties with substantial mining activity are more likely to be coal fired and to purchase more within political boundary coal. These results are robust to including flexible controls for the distance from power plants to mines. Given that we find that mines have access to "captive" same jurisdiction demand, we predict that the phase out of this polluting industry will be slower than has been previously suggested. While the local community gains from extending coal mining, this pursuit of local self-interest imposes social costs because coal mining and coal burning has significant environmental consequences.

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Introduction

To mitigate the global challenge of climate change, nations must burn less coal. In recent years, the share of U.S electricity generated by coal has fallen from nearly 50% to 33%. The U.S reduction in coal use for generating power is especially notable because it has occurred without the U.S imposing carbon pricing or a carbon tax (Cragg et. al. 2013). The substitution away from coal is mainly due to the rise of the adoption of fracking technology and some states sharply ratcheting up their renewable portfolio standards (Venkatesh et al 2012 and Burtraw et al, 2012).

While environmentalists cheer for coal's sunset, there are interest groups with strong incentives to protect this declining industry. Reduced power plant demand for coal imposes spatially concentrated costs borne by traditional coal mining communities in states such as West Virginia, Kentucky, and Wyoming, and the low skill workers who engage in mining and providing services in mining areas. There were 261 coal mines in the United States that shipped coal to the electricity sector in 2014. These mines tend to be in rural areas where the population is white and has less education and fewer alternative job prospects than the national average.

In this paper, we document evidence that power plants are more likely to use coal to generate power and are more likely to purchase locally mined coal if the power plant and the coal mine are located in the same state, county, or congressional district. This finding is robust to flexibly controlling for the distance between mines and power plants. Our explanation for this *within political boundary trading* focuses on political intervention. Elected officials such as a mining state's governors, Congressmen and local officials have an incentive to help their constituents. Miners and the members of their communities are typically low skill people with long time roots to the area who do not have clear industrial alternatives. Local elected officials in coal states are aware that their constituents face significant dislocation costs and seek to protect them from long-lasting negative income shocks by stabilizing demand for their constituents' output.[1]

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[1] Recent work by Autor, Dorn and Hanson (2016) documents that local labor markets only slowly re-equilibrate after a reduction in local demand. They use the China joining the WTO which accelerates China's exports to study this. In their setting, U.S areas (commuting zones) differ with respect to their

Officials have various powers to encourage the local power plant to purchase coal from the mine to increase local demand. West Virginia provides incentives that reduce the production cost for local coal mines and encourages local buyers to buy from these sellers.[2] Maryland and Virginia offer a $3 per ton tax credit for utilities buying in-state coal (Bowen and Deskins 2015). Oklahoma offers credits of $5 per ton to both coal mines and power plants, effectively contributing $10 to every ton of Oklahoman coal that is burned for electricity generation in the state. Further, in the mid-2000s, Oklahoma enacted a law requiring that power plants purchase at least 10% of their coal from in-state coal mines. This law, intended to protect Oklahoman mines from competing Wyoming coal, was eventually struck down by the U.S. Supreme Court.

A distinctive feature of the coal industry is that its consumption and production entails large Pigouvian externalities (Davis 2009, Mueller and Mendelsohn 2012). In such a case, protectionism causes two inefficiency losses. First, there is the usual deadweight loss from not exhausting the gains to trade between demanders and low cost suppliers. Second, there is deadweight loss caused by prolonging the use of a dirty technology that causes social harm. By supporting local coal mines, the transition to natural gas and renewable electricity sources is slowed and this results in additional emissions of greenhouse gases and criteria air pollutants. Since climate change is a global externality, local and state elected leaders have weak incentives to internalize this externality. Instead, they have strong incentives to protect local coal mines as this improves the local economy through providing high-paying jobs as well as indirectly through the local spending multiplier.

We study the environmental implications of local protectionism for local air quality and overall CO2 emissions. By quantifying the social costs associated with protection of a declining industry, this piece of our empirics is the mirror opposite of other research that attempts to

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direct competition with China. Those geographic areas in direct competition with China suffer long run effects.

[2] One proposal for a type of tax deduction that would provide additional benefits for coal sold within the state was introduced in the 2014 legislative session as the West Virginia Coal Employment Enhancement Act (Senate Bill 604/House Bill 3072). Though the bill did not passed into law, it would have created a new tax incentive for sale of coal mined within West Virginia to power producers and industries that consume the coal within the state.

measure the social benefits of protecting infant industries (see Goodstein, 1995). This literature argues that society ostensibly props up infant industries because they convey a social good (Melitz 2005).

The Spatial Economics of Coal Trading

We present a simple framework for studying bilateral trade between power plants and coal mines. In a later section, we will introduce several nuances related to issues such as the ownership structure of the coal fired power plants, coal quality, and environmental regulation of power plants. Our starting point is that the buyers and sellers of coal have weak incentives to internalize the social consequences of their mutually beneficial trade.

Consider the case where coal is produced by a set of spatially-differentiated mines using a homogeneous production function, and converted into electricity using a homogeneous production function by power plants which seek to minimize their cost of production subject to generating a given level of electricity.[3] Further, suppose there are no long term contracts such that coal is sold on a spot market.

Given these assumptions, we expect that a gravity model of bilateral trade will have significant explanatory power. If coal markets are competitive, power plants will purchase coal from the closest mine, at a price that is at most equal to the production price of coal plus the transportation cost from the second-closest mine. If a power plant purchases from a mine that is not its closest prospective trading partner, it is indicative of deviation from perfect competition.[4]

The cost of coal transportation is a substantial portion of total coal generation costs. Shipping coal by rail – the predominant transportation method – generally costs on the order of 2-8 cents per ton per mile, so each additional 100 miles of transportation increases the delivered price of coal by $2-$8 per ton. Given that coal prices are generally below $50 per ton; power plants have a substantial incentive to purchase coal from close mines. These costs are a

[3] Even publicly-owned utilities that own their own power plants should purchase from other power plants if the electricity can be provided at lower cost.

[4] Neither coal production nor electricity generation technologies are homogenous, of course, and other considerations, such as uncertainty about mine production, could lead power plants to seek out more distant trading partners.

significant portion of total operating costs for a coal-fired power plant. Based on EIA reports of average operating expenses and average heat input for coal-fired power plants, the transportation costs of moving coal 100 miles would account for about 0.2 cents per kWh, around 5% of total operating expenses.[5] In 2012, the median power plant purchased 960,000 tons of coal while the median coal mine delivered nearly 1.2 million tons of coal.

Coal Area Elected Officials as "Local Pareto Planners"

Elected officials in coal areas have strong incentives to take actions that increase the demand for coal. Mining is a high paying job for low skill non-urban workers. The average salary for all U.S. coal miners was $82,000 in 2013 according to the National Mining Association. Coal mining activity is concentrated in relatively rural communities and requires relatively little education (Bell and York 2010). Mining jobs creates a local multiplier effect in their community, resulting in additional job opportunities and economic activity.

By boosting coal demand and raising local wages and home prices, elected officials can achieve stability for local families. Stable families and their communities go hand in hand in areas that do not have alternative industries to turn to. Our examination of the sunset of the coal industry revisits recent research that has examined how rural communities have gained from the fracking boom (Feyrer, Mansur, and Sacerdote (2015) and Alcott and Kenniston (2014), DeLeire, Eliason and Timmins 2014)).

Families enjoying job security are less likely to experience divorce, substance abuse and economic hardship. Labor economists have emphasized the possibility of scaring due to duration dependence associated with experiencing unemployment (Borjas and Heckman 1980, Black and Sanders 2002, Black, McKinnish and Sanders 2003, 2005a, 2005b). If coal miners lose their jobs

[5] EIA quotes 3.904 cents per kwh for fossil steam plants in 2014 and 0.00052 tons of coal per kwh. We assume a transportation cost of $4 per 100 miles, the midpoint of our range.

and become unemployed, the duration dependence hypothesis posits that they will become increasingly less likely to find a new job and are unlikely to find a new job that pays as well.

The children who grow up in such families are likely to be especially affected. Based on Heckman's dynamic complementarity model, the early years of life are crucial for raising the chances of a child achieving her full potential (Heckman 2007). If the household's income declines and if the family divorces, such a child is less likely to succeed. This sad dynamic shows how reduced coal demand translates into widening income inequality and increased poverty in these rural areas.

Elected officials in coal areas will understand this dynamic and this creates an incentive (both due to altruism for constituents as well as the desire to be re-elected) to engage in a type of Keynesian demand management in which the local politicians use their clout to encourage same state coal power plants to "buy locally". In this sense, local elected officials are a type of "Pareto Planner" (abstracting from the pollution externalities that we discuss below).[6]

Such politicians have influence over several possible policy levers (see the introduction for examples). Power plants face land use issues related to permitting and environmental regulations. One could imagine, for example, that prior to the introduction of national regulations on coal ash waste disposal, that legislators who wished to protect the coal industry could enact relatively less stringent rules on ash disposal. Alabama, which locally produces about 40% of its consumed coal had no state-level oversight or regulation of its coal ash ponds. Similarly, the water temperature discharged by power plants is regulated in part by the state, and state environmental protection boards could opt to waive maximum water temperature regulations for

[6] We recognize that there are alternative mechanisms that could contribute to within jurisdiction coal trade. Past investments by local power plants to optimize the power generation process as a function of local coal purchases may create a "lock in" effect through the asset specificity of past investments (Joskow 1985). One possible explanation for why the two parties would be willing to "lock in" to a long term relationship is because they anticipate that there will be less future political risk between two contracting parties since they are both represented by the same political leaders.

coal plants who purchase in-state coal. Moreover, in the case of power plants that are owned by utilities, politicians can directly influence the approval of increase in regulated electricity rates.

Past work in urban economics has explored the spillover effects that key decision makers take into account when making investment decisions. Henderson and Mitra (1996) discuss the incentives of an edge city developer. Such a developer collects more money for property sales if he makes strategic investments that maximize positive synergies in land use and minimizes negative synergies in land use. Gould, Pashigian, and Pendergrast (2005) explore a similar idea in their work on shopping malls. By offering a rent discount, the mall owner can attract an anchor tenant who attracts plenty of customers. Anticipating that there will be walking traffic, other mall tenants are willing to pay more for commercial leases to have access to these potential customers. In our case, as well as the edge city and shopping mall cases, there are localized externalities that individual decision makers (i.e. the power plants) might have ignored.

Environmental Externalities Imposed by Coal Production and Consumption

While local elected officials have strong incentives to internalize the direct economic consequences for their constituents, they have weak incentives for internalizing pollution costs if such costs are borne by people who live outside of the jurisdiction. Such free riding has been quantified in the case of international river pollution (Sigman 2001) and rivers crossing Chinese provinces (Kahn, Li and Zhou 2015). Such officials have even weaker incentives to internalize the greenhouse gas production implications of encouraging coal consumption. In this case, the externality's costs are borne at the global level. Coal burning features a high carbon intensity of roughly 2300 pounds per MWH of power. In addition to producing this global externality, coal use by power plants create many local negative environmental and health externalities. These externalities are shown to reduce nearby home values (Davis 2011).

The Empirical Strategy

Figure One maps the 372 coal fired power plants in the United States and the 161 coal mines in the U.S that either purchased coal in 2014 or shipped coal to the electricity sector in 2014. Several clear geographic patterns emerge. Coal mining is concentrated in Appalachia (Kentucky, West Virginia, Ohio and Pennsylvania), in southern Illinois and Indiana, and in Wyoming. While the majority of mines are in the Appalachia region, the largest mines are in Wyoming, which has relatively low-quality but easily accessible coal deposits with low sulfur content. Coal power plants exist throughout the country, but are most prevalent in the Midwest, Mid Atlantic, and South. For each power plant, we calculate its distance to the coal mines with which it trades. Table 1 reports the empirical distribution of these distances where we weight the observations by the quantity of coal the power plant consumed in 2014. We find that 30% of total power plant coal is purchased from mines that are less than 80 miles away. This is clear evidence of significant local purchasing.

Our estimation strategy for studying the quantity, pricing and the propensity to lock into long term contracts focuses on the bilateral distance between any pair of power plants and mines and the role of within political boundary trades. These equations bear a close similarity to the standard gravity models from international trade. The distinctive feature of our econometric framework is the vector of dummy variables indicating if the origin mine and potential destination power plant share a common political jurisdiction.

Coal Purchases and Quantities

We estimate a series of regressions to test for “within border” effects. In each of these regressions, we seek to test for protectionist behavior based on whether we observe “excess trade” when the power plant and the coal mine are located inside the same geographic jurisdiction. We define a dummy variable, $Trade_{ijt}$, to be that equals one if power plant i and mine j trade at time t and estimate the probability that $Trade_{ijt}$ equals 1 based on a series of political boundary controls.[7] In this, and in most of our other specifications, the unit of

[7] Our empirical strategy resembles the approach adopted by Hillberry and Hummels (2003) to study trade flows.

observation is the power plant-mine-year. We model this probability of trade using a logistic regression of the form;

$$prob(Trade_{ijt}) = f\big(g(distance_{ij}), Border_{ij,} Plant\ Attributes_i, Mine\ Attributes_j, Time\ Contol_t\big)$$

(1)

We also estimate versions of equation (1) using a “Heckit” and where we study the log quantity of trade conditional that a positive amount of trade has occurred.

In this equation, the key explanatory variables of interest are the vector of border dummies. We include three dummies indicating whether the mine and the plant are in the same state, same Congressional District and the same county. A key point to note is that we flexibly model the role of distance on trade. This g() polynomial and splines that we report below allow us to control for the standard gravity effects and proxies for transportation costs.[8]

A Regression Discontinuity Test

One potential concern is that our cross-political boundary results might merely reflect non-linear distance effects that are not captured by our distance controls. In order to address this concern, we estimate the effect of the political boundary on coal trading in a regression discontinuity framework in the spirit of Black (1999) and Holmes (1998)**.**

Specifically, we limit our sample to only counties along state borders that are adjacent to a county in another state that also has a coal-fired power plant. There are 69 counties that both have a coal-fired power plant and are adjacent to a county in a different state that also has a coal fired power plant and a total of 89 unique county boundary pairs (some counties appear in more

[8] In an appendix, we estimate the relationship between distance and the EIA-reported transportation costs between states. Distance and year fixed effects result in an adjusted R-Squared of approximately 0.35.

than one pair). There are 105 power plants in these 69 counties. We create a set of adjacent county fixed effects for each pair of cross-state adjacent counties. Figure 2 shows the set of power plants in this sample and each pair of adjacent-county power plants receives a unique fixed effect. For example, along there are two power plants in Clark County, Nevada and one power plant in neighboring San Bernadino County, California. Each of the three power plants receives a value of one for the Clark County-San Bernadino pair dummy variable and all other power plants in the country receive a zero for this pair fixed effect. By adding these fixed effects to our regressions, we control for the effect of the general location of power plants (e.g. distance to population centers).[9]

Controlling for distance, we estimate a linear probability model to explain the probability that power plant, i, and mine, j, transact as being determined by

$$prob(Trade_{ijt}) = f\left(g(distance_{ij}), \pi_p, Border_{ij,} Plant\ Attributes_i, Mine\ Attributes_j, Time\ Contol_t\right)$$

which differs from our primary estimating equation because we now include a set of π_p county border fixed effects. Each county border pair, p, is defined as a set of two neighboring counties in different states, and for each county border pair we construct a dummy variable that is equal to one if power plant i is in either county comprising county border pair, p. Initially, we do not restrict the set of coal mining counties with which a power plant can trade, so for each of our 105 power plants we observe 400 potential trading partners in each year. Our unit of observation is the power plant-mine-year. Next, we further restrict the sample so that each power plant can only buy coal from mines in its own state or in its adjacent county's state.

Figure 3 shows the set of cross-state power plant pairs in Ohio, Kentucky, West Virginia, and Indiana, as well as the mines in each of these states. Each of the power plants along the Ohio-West Virginia border (blue triangles) have a choice set of coal mine trading partners of

[9] These fixed effects improve the identification of our cross-state boundary estimates under the assumption that any transportation-related constraints that are not adequately captured by our distance polynomial are comparable in adjacent counties.

Ohio or West Virginia mines (blue circles). Similarly, each of the power plants along the Indiana-Kentucky border (red triangles) have a choice set of coal mine trading partners of Indiana and Kentucky mines (red circles). As in the unrestricted regression discontinuity framework, each pair of adjacent counties receives a fixed effect to control for unobserved regional variation.

Price and Contract Characteristics

Next, we consider differential behavior in several of the characteristics of trades. In this analysis, we restrict our study to only trades, rather than all possible power plant-mine interactions. We also focus on a monthly time-scale (the sharpest time-step reported in our data) rather than an annual time-scale to avoid issues associated with aggregating prices and contract characteristics over months in a year.

First, we estimate

$$price_{ijt} = f\big(g(distance_{ij}), Border_{ij,}Plant\ Attributes_i, Mine\ Attributes_j, Time\ Contol_t\big) \quad (4)$$

Where $price_{ijm}$ is the delivered price of coal in dollars per MMBTU from powerplant i to mine j in month t.

We then estimate two models regarding the contractual characteristics of powerplant-mine interactions. Joskow (1985) notes the importance of relationship-specific capital in the coal market, with larger quantity contracts tending to be longer duration contracts. As a corollary, we look for the presence of relationship-specific political capital in coal trades, expecting that plant-mine pairs in which political capital is prevalent or more important will be more likely to lock into long-term contracts than plant-mine pairings in which political capital does not exist. Similarly, coal mines that have guaranteed a level of demand by entering into long lasting contracts will be more likely to hire or retain workers than plants that have not guaranteed trading partners.

First, we explore whether or not powerplant-mine pairs that fall inside the same political boundaries are more likely to engage in long-term contracting that powerplant-mine pairs that do not fall inside the same political boundaries. We also examine the intensive margin of contracts.

Power Plant Placement and Closures

If the location of power plants themselves are affected by political pressure from mining communities then our estimates of coal mine-powerplant interactions will underestimate the full impact of political support. In order to examine the effect of local mines we estimate a multinomial logit of whether a county has a coal-fired power plant, a non-coal fired power plant, or no power plants as a function of whether or not the county has an in-state or in-county coal mine. We control for the Euclidean distance between the county centroid and the closest coal mine. As a result, our political boundary effects are estimated holding constant the cost associated with moving coal from the closest mine to the power plant. Because power plants are relatively likely to be positioned near population centers, we include the county's population in the power plant siting decision.

Competition from natural gas and from regulation has led to substantial reductions in coal-fired electricity capacity over the past decade. Given that low natural gas prices are likely to continue in the near-term, one might suspect that market forces will cause coal plants to close, precluding any ability of political protectionism to stimulate coal demand. In order to test for this concern, we examine the universe of coal-fired generators and estimate the likelihood that a generator is retired by 2014 as a function of whether or not the generator has an in-state coal mine[10]. We estimate the logit regression

$$Prob(retired_g) = f(Plant\ Characteristic_g, In\ State\ Mine_g, Distance\ to\ Mine_g). \quad (5)$$

If the coefficient on our In State Mine is less than zero, power plants with an in-state coal mine are less likely to retire than plants without an in-state coal mine, even after controlling for the distance to the geographically closest potential trading partner.

[10] The EIA reports retirements at the generator-level rather than the plant-level.

In each case, our key hypotheses focus on the coefficient estimates for our border variables. The border variable in our estimating equations indicates a series of dummy variables indicating whether mines and plants cross a state, congressional, or county boundary. Our identification strategy relies on the assumption that our flexible controls for distance capture any affect associated with transportation costs between poweplants and mines. Our sunset hypothesis posits that all else equal, there will be more coal trade when the buyer and seller are in the same jurisdiction, and that the contractual lock-in will be stronger. This econometric strategy combines the standard trade gravity model with Holmes' (1999) borders approach. In a section after we present our main results, we will test how these border effects vary over time.

Power Plant and Mine Data

The EIA collects data on fuel deliveries to the plants in the power sector. Since 2008, fuel delivery data are reported on the EIA-923 form, which covers monthly fuel deliveries by both utilities and non-utility deliveries. Between 2002 and 2008, utility fuel deliveries were reported through the FERC-423, while non-utility deliveries were collected via survey with the EIA-423 for plants in excessive of 50 MW. Prior to 2002, only the FERC-423 existed, and collected only utility fuel purchases.

Because the earlier data do not report the mine-specific MSHA ID, we treat a mine-observation as the mine's county of origin, which is reported much more consistently and aggregate coal deliveries to the plant-coal county-year (aggregating across months in the year). We then construct a matrix of the unique combination pairs of the 410 coal mine counties and 516 power plants and 25 years in our sample. For each mining county, we calculate the latitude and longitude of the county centroid and compute the distance between the county centroid and each power plant. Finally, we calculate the total annual quantity of coal that is shipped for each county and the total annual quantity of coal that is received for each power plant and drop plant-coal county-year observations in which the plant received no coal or the coal county shipped no coal. This leaves 1.9 million observations from the initial matrix of 5.2 million plant-mine-year combinations.

Similarly, we create a matrix of plant-coal mine-year unique combinations for the 2008-2014 years in which the mine-specific MSHA ID is reported. In this case we compute the distance between the latitude and longitude of the coal mine and the latitude and longitude of the coal power plants, rather than county centroids. Again, we drop observations in which total plant purchases or total mine deliveries is zero. We then overlay state, county, and congressional boundary shape files onto our geospatial data on power plant and coal county/mine location and create indicator variables for whether a power plant – coal county/mine combination are in the same state, county, or congressional district.

In both cases we supplement the EIA/FERC data with characteristics of the power plant and the mines. In the case of the power plant characteristics, we merge an identifier from the EIA 923 which indicates whether the utility operating a power plant is a municipally-owned, investor-owned, a non-utility independent power producer, etc. For the coal mine, we merge in data on whether a coal mine is an underground or surface mine, and on the local economic conditions in the county of the coal mine. In the recent EIA sample, the delivered cost of coal is also reported for each transaction from plants operated by a regulated utility, including the ash, sulfur, and heat content for the fuel.

Results on Coal Trading

As shown in Table 2, coal purchases are generally local. Columns 3 and 4 show the percentage of coal deliveries to power plants in each state that were from in-state and out-of-state coal mines, respectively. Columns 5 and 6 show the percentage of coal deliveries from mines in each state that were to in-state and out-of-state power plants, respectively. Columns 4 and 5 are blank if a state does not have any coal mines that shipped to the power sector throughout the duration of our sample.

The average state receives 24% of its total coal consumption from in-state mines, although this is biased downward because many states do not produce coal at all and must purchase all of their coal from out-of-state mines. The average across only the states that produce coal is 48%. The states that receive the lowest-percentage of total coal purchases from in-state mines were Kansas (20), Maryland (24), Missouri (29), Oklahoma (40) and Tennessee (47). In each of these states, coal is the dominant source of electricity generation but coal mining is a relatively small industry.

Coal Purchases and Quantities Results

The prevalence for intra-state trades are not driven merely by distance. Across each distance specification, we consistently find a negative and statistically significant effect of being across state lines on the probability that a power plant will purchase coal from a mine. Table 3 presents these results. A power plant is 0.3 percentage points less likely to purchase coal from an out-of-state mine than from an in-state mine that is the same distance away. This effect is quite large in context. Across our entire sample, the probability that a plant-mine combination engages in a trade in a given year is about 2 percent. We find even stronger effects at the county boundary. Cross-county trades are approximately 2 percentage points less likely to occur than intra-county trades. The effect of the congressional district is comparable in magnitude to the effect of the state boundary. These effects are consistent regardless of the approach to controlling for transportation distance using either polynomials or a restricted cubic spline. Using the 10 mile bins – the finest granularity of distance control – the state effect is reduced slightly. The state boundary is associated with a 0.2 percentage point reduction in the probability of a trade. The effect of the county boundary is reduced by an order of magnitude, and the statistical significance is weaker for both the county and congressional boundary estimates. Also, note the relationship between the political boundaries. A mine that is not in the same state as a power plant is obviously not in the same county or congressional district as the power plant, so the net effect is the sum of the three coefficients.

Unsurprisingly, the probability that a power plant and a mine trade is increasing in both power plant purchases and in mine shipments. This indicates that plants that buy a lot of coal tend to purchase from more mines than plants that buy a relatively small amount of coal. Similarly, mines that produce a lot of coal sell to more power plants than small mines.

We find similar results when we examine not only the probability of a trade occurring but the amount of coal that is purchased. These results are reported in Table 4. A power plant will buy approximately 8,000 fewer tons of coal from an out-of-state mine than it would buy from an in-state mine of comparable distance. The effect of the congressional border is approximately

100,000 tons, around eight times the magnitude of the cross-state effect. The effect of the county border is substantial, a mine that is across a county border from a power plant will sell 1.4 million fewer tons of coal than a mine that is inside the same county as the power plant. In each case except the cross-state effect in the splined distance control and the state and congressional boundary effect in the ten-mile bins, the estimates are strikingly similar across distance controls.

The regressions presented above include all interactions – both positive quantities as well as interactions of zero quantity (i.e. no trade occurred). If we limit our sample to only the interactions that resulted in trades, we can estimate the effect of political boundaries on the intensive margin of coal trading. Table 5 presents the regression results for this specification. Only the intra-county effect persists on the intensive margin, except in the case of the 10 mile bin where we find suggestive evidence that plants buy more from cross-state mines than in-state mines. Surprisingly, the magnitude of the effect is only slightly smaller than the case in which we consider the quantity in all observations.

Evolution of the Boundary Effect Over Time

The coal sector, the electricity sector, and the labor conditions in coal mining communities have evolved over time. As economic conditions worsen in coal mining communities, protecting coal mining jobs grows in importance and politicians should be relatively more willing to exert pressure on power plants to support the local industry. Similarly, the extent to which electricity generation decisions are exposed to political pressure has changed over time. One might expect, for example, that government-owned utilities would be more susceptible to job protectionary pressure than independent power producers who would be more concerned with profit maximization and less concerned with local stakeholders. We would therefore expect a smaller border effect when a greater proportion of power plants were controlled by independent power producers. Cicala (2014) documents that when utilities were forced to divest their power plants to new owners during electricity deregulation that fuel procurement costs declined for coal plants. If political protectionism is responsible for some of Cicala’s (2014) effect, we would expect our border protection estimate to be smaller after deregulation than before it.

In order to investigate this dynamic over time we estimate our primary specification as a cross section for each year between 1990 and 2014, dropping the time specific fixed effects. Estimating the model separately for each year, rather than estimating a single model with interactions between the time fixed-effects and the political boundary variables lets our distance control adjust over time so that changes in the political protectionism over time are not confounded with changes in shipping infrastructure or cost.

Figures 3-5 show the 95 percent confidence interval on different state, different county, and different congress over time. Each political delineation experienced a roughly similar pattern. From 1990-1995, the coefficients declined indicating relatively greater protectionary behavior. Between 1995 and approximately 2000, there was relatively less protectionary behavior. Protectionary behavior was relatively consistent between 2000 and 2006 after which it generally decreased through 2014.

The majority of our sample falls after electricity deregulation was already in effect or being implemented so we do not have pre-deregulation coefficients with which to compare against the early 1990s results. Still, it is surprising that protectionist behavior is growing during the expansion of deregulation during the early 1990s. This provides some suggestive evidence our political jurisdiction effect is not driving the reductions in procurement costs noted by Cicala (2014).

We also note that changes in political climate throughout our sample period. The magnitude of the boundary effect is generally increasing (less local purchasing) during the 1990s, the late 2000s and the 2010s, while it is decreasing (more local purchasing) during the early and mid-2000s. Note that the 1992-2000 and 2008-2014 periods with declining local protectionary power aligns with a Democratic Presidential Administration, while the increasing protectionary power of the 2000s aligns with the Republican Bush Administration. We do not, however, attempt to assign any causality between the political climate and the effect.

Regression Discontinuity Results

Our regression discontinuity models presented in Tables 6 and 7 find further evidence of political boundary effects in coal purchasing. In estimating equation (2), we include all mines as potential trading partners, each of the 105 power plants in the 69 counties that both have a coal-fired power plant and border a county with a coal-fired power plant can trade with any of the 400 mines.

We find that the county boundary results in approximately a 4 percentage point reduction in the probability that a power plant purchases coal from a coal mine. Again, this effect is robust to a range of controls for the distance between the power plant and the coal mine. The different state boundary also corresponds to a congressional district and county boundary which we omit from the regression discontinuity framework. Our regression discontinuity approach is finding larger overall effects than our baseline specification. The combined effect of the three boundaries in our baseline results is around 2-3 percentage points.

Next, we further restrict our regression discontinuity framework by limiting each pair of adjacent-county power plants to only being able to purchase coal from mines in either state of the adjacent counties. For example, the power plants in Mobile County, Alabama and Jackson County, Mississippi would have as potential trading partners the coal mines in Alabama and Mississippi but we drop the power plant-mine observations in which the mines are in other states. In this specification, the border variable captures the relative difference in the probability of a trade between each mine in Alabama and the plants in Mobile, County Alabama and Jackson County, Mississippi. Our neighboring county--pair fixed effect captures unobserved characteristics of the Mobile/Jackson area and the remaining difference in probability is assigned to the border effect. The results are slightly larger in the specification that limits a power plant's potential trading partners to only the in-state mines on either end of the border. In this specification, the boundary effect is in the neighborhood of 5 percentage points.

Price and Contract Characteristics Results

When we focus on the characteristics of the trades (i.e. transacted price, contracted vs spot, and contract duration), we substantially reduce our sample size because we do not observe trade characteristics for trades that do not occur. After focusing only on trades that occur, the correlation between our cross-boundary variables increases because many of the, for example, different-county but same-state observations that induced orthogonality between the political boundary controls did not result in trades. As such, we highlight the results of F-tests for the joint significance of our political-boundary variables in each of these cases.

Evidence of jurisdictional effects on price after controlling for distance are mixed, at best. The point estimates in Table 8 indicate that there is a price discount associated with in-county coal purchases of about 12-15 cents per million BTUs. This suggests that coal mines are able to extract higher prices from power plants that are outside their county than from those who are within the county. Again, these regressions include controls for the distance between the power plant and the coal mine, so it is unlikely that this is simply reflecting transportation costs. However, only in the case of the spline distance control is there any evidence that the cross-boundary controls are jointly different from zero. This would imply that when all of the boundary controls are taken together, that mines are not able to extract different prices from plants that are across jurisdictional lines than from plants within their jurisdiction. Similarly, when we control for distance using the ten mile bins, we do not find statistical significance for any of our key explanatory variables, and the F-test suggests joint insignificance. The weak evidence of plants extracting lower prices from in-state mines provides further suggestive evidence that the relationship between plants and mines is driven by a political mechanism rather than a cost minimizing mechanism.

In Table 9 we estimate the effect of our boundary effects on the probability that a trade is associated with a long term contract rather than a spot trade. Similarly, in Table 10 we estimate the effect of our boundary effects on the length of the contract for those trades that are associated with contracts. Each of our political boundary controls is negative but statistically insignificant when we examine whether power plants and mines enter into contracts or interact on the spot market. We also find that both the county and state boundaries affect contract duration. Specifically, we find that contracts are longer between power plants and mines that are within the same but shorter between power plants and mines that are within the same state. The magnitude of the two coefficients are relatively similar but of opposite signs, indicating that mines and power plants that are in the same state but not in the same county, tend to be shorter than contracts between cross-state firms as well as shorter than contracts between intra-county firms.

These results are broadly consistent with Joskow (1984) who attributed the longer duration of relatively high quality contracts to relationship-specific capital. Indeed, our controls for trade quantity align with Joskow. Moreover, the effect of the boundary control on contracting duration and prevalence indicates the potential for a different type of relationship specific capital. While Joskow (1984) focused on the physical characteristics of the plants and the coal that they burned, our result is consistent with relationship-specific political capital inducing power plants and mines to operate together.

Power Plant Placement and Closures Results

In Table 11, we also find a jurisdictional effect in power plant placement decisions. After controlling for the distance to the closest coal mine, the probability of having a coal fired power plant in a county is about 0.5 percentage points higher if there is a coal mine in the county than if there is not a coal mine in the county. Note that this indicates that even after controlling for the distance to the closest coal mine, a county is more likely to have a coal burning power plant if there is an in-county coal mine. Surprisingly, the effect of having an in-state but out-of-county coal mine actually serves to decrease the probability that there is a coal power plant in the county. This effect is quite small relative to the in-county effect.

In Table 12, we show a jurisdictional effect in coal power plant closures. A power plant (or rather a generator) that is in a state with a coal mine is approximately 7 percentage points less likely to have closed by 2014 than a coal power plant without a potential in-state trading partner.

Environmental Implications of Within Coal Mining States Transactions

We estimate the environmental implications of local coal protectionism in two complementary fashions. First, we estimate the local impacts of coal consumption using data on ambient air pollution levels in counties that have power plants that purchase coal for the electricity sector and in surrounding counties. Second, we estimate aggregate emissions from the electricity sector due to coal protection. The former approach allows for a more specific consideration of who is affected by pollution, while the latter approach provides an aggregate effect of coal mining protection that takes into account general equilibrium impacts in the electricity sector.

In order to examine the effect of coal protectionism on ambient pollution, we obtain daily pollution monitor data on SO2 and PM from the EPA's AQM database. We then aggregate these data to the county-month level and merge them with the total amount of delivered coal to a county for electricity generation, as derived from the fuel deliveries data. Finally, in order to examine total emissions, we obtain CO2, SO2, and NOx emissions from the EPA's Air Markets Program Data (AMPD). AMPD reports emissions for each power plant that is covered under any air markets program. Most power plants are covered by at least one air markets program in the latter half of our sample. We then aggregate CO2, SO2, and NOx emissions across power plants in each NERC region up to the monthly level.

In order to examine the effect of coal protection on ambient are quality, we estimate

$$Pollution_{ct} = f(Coal\ Consumption_{ct}, Time\ Trend_t, County\ Characteristic_c)$$

(6)

where Pollution is the average measurement of ambient pollution levels for sulfur dioxide and particulate matter, and Coal Consumption is a matrix of coal deliveries to a state, county, and neighboring counties.

Similarly, in order to examine the effect of coal protection on total greenhouse gas emissions, we estimate

$$f(Emit_{nt}) = f(In\ State\ Coal\ Mines_{nt}, NERC\ characteristics_{nt}, Time\ Trend_t)$$

where Emit is the emissions of CO2, SO2, and NOx from a NERC region.

(7)

If coal power plants with nearby coal mines are more likely to continue to operate – or operate at higher levels of generation – than coal power plants without nearby coal mines, we would expect a positive coefficient on the In State Coal Mines variable. This variable is defined as the percentage of coal power plants in a NERC region that have an in-state coal mine. A NERC would receive a value of 100 if every state in the NERC region produced coal, and a value of 0 if no states in the NERC region produced coal.

Tables 13 and 14 present these regression results. As we would expect purchases of coal by electricity generators at the state level results in increased SO2 and PM concentrations in counties within that state. Based on our OLS regression results presented in Table 4, we would expect that the effect of having an in-state coal mine would increase SO_2 concentrations by approximately 0.008 parts per billion for each coal plant in the state.[11] Similarly, an in-state coal mine would increase PM concentrations by approximately 0.008 micrograms per cubic meter. We generally fail to find local effects of county-level or neighboring county-level generation. Strangely, we find that coal consumption is associated with decreases in PM_{10} concentrations in the county of purchase. Given that coal is only one of a large number of components that affect PM levels it is likely that other PM generating behavior is negatively correlated with coal generation.

We also find that the percentage of power plants in a NERC region that have an in-state coal mine trading option leads to increases in CO_2, SO_2, and NO_x emissions. In the case of CO_2, for every percentage point increase in the proportion of power plants in a NERC region that are close to an in-state mine, an extra 2.3 million tons of CO_2 is emitted. Assuming a social cost of carbon of $40 per short ton, these results suggest that each percentage point increase in the number of coal-fired power plants in a NERC region with a potential in-state trading partner results in $92 million per year in added social costs. Based on the average prevalence of in-state mines in our data set (53%), this would indicate that around 8% of CO_2 emissions from the electricity sector are attributable to this effect.

Conclusion

The phase out of coal would be likely to be a Hicksian Pareto improvement for the United States. Based on a Social Cost of Carbon of $30 a ton, the current national externality from coal associated with in-state mine purchasing (abstracting from criteria air pollution costs) was $4 billion in 2014.[12] While it may be socially efficient to phase out coal, the costs of such a transition are spatially concentrated.

[11] Table 4 indicates that having an in-state mine would raise coal shipments to each coal plant by around 10,000 tons. Because each of these plants would increase total state generation by 0.01 million tons the net effect on the state would be 0.07*0.01*number of plants.

[12] 2600000 tons of coal * 53 percent of plants close to an in-state mine * 30 dollars per ton = $4.1 billion

Local officials in coal areas are well aware that many of their constituents depend on the continuing viability of the coal industry and they are aware of the negative dynamics that this industry faces. We have introduced a detection approach to measure "excess" within border transactions. Our empirical research design exploits the fact that coal mines and power plants vary with respect to their geographic location. Some lie within the same political jurisdiction while others do not. This variation allows us to use a flexible distance polynomial between pairs of power plants and coal mines to recover key border effects. We document an increased likelihood of trade and larger trade quantities when partners are within the same state, county, and congressional district. We have argued that these effects are no accident as local officials internalize the benefits of coal's prolonged sunset but they ignore the social environmental costs associated with such implicit subsidies. The costs of the CO2 emissions associated with this protectionism are substantial, nearly $100 million a year in excess social carbon costs. Still, sustained low natural gas prices may limit the duration of coal's sunset as market forces drive additional natural gas capacity to supplant coal plants. Given the proximity of environmental tipping points associated with particular levels of CO2 concentrations as well as uncertainty about energy policy under the Trump Administration, coal protectionism may still cause major environmental costs.

Given the durability of housing capital and the built up social networks established in mining areas, its residents face both migration costs and asset losses if the demand for coal mining declines. Such individuals face a fundamental job retraining challenge in transitioning to other jobs. During a time of great concern about income inequality and concern about fighting climate change, environmentalists/progressives face a challenge of promoting policies that phase out coal without increasing rural poverty and family dislocation. Republican leaders do not face this tradeoff because of their general dismissal of the climate change challenge.

Harstad (2012) has proposed a mechanism of "buying coal" from marginal unregulated coal producers and then keeping these purchased deposits in the ground after restricting production among regulated coal producers. His proposal could be modified to address the problem of coal's sunset by purchasing domestic coal reserves and by paying coal miners to mine the purchased coal. This would compensate mine owners and workers for their losses associated with natural gas production and environmental regulations. Future research could explore how such proposals could be augmented to buyout the working right from current coal miners. In the late 1990s, the major cigarette manufacturers settled with the tobacco growing states to compensate tobacco growers for their losses associated with the falling demand for tobacco. This case may offer insight into a possible Coasian strategy for accelerating the sunset of coal production in the United States.

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Tables and Figures

Table 1: Quantity-Weighted Distribution of the Distance between Coal Mines and Power Plants in 2014 (Miles)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
2.5	14.5	26.4	79.0	177.9	333.2	632.4	785.1	904.4	1058.0	1793.4

Table 2: Coal Consumption and Deliveries by Source and Destination

State FIPS	State Name	In State Consumption Percentage	Out of State Consumption Percentage	In State Delivery Percentage	Out of State Delivery Percentage
1	Alabama	0.4	0.6	0.96	0.04
4	Arizona	0.4	0.6	0.72	0.28
5	Arkansas	0	1	0	1
6	California	0	1	-	-
8	Colorado	0.58	0.42	0.49	0.51
9	Connecticut	0	1	-	-
10	Delaware	0	1	-	-
11	District of Columbia	0	1	-	-
12	Florida	0	1	-	-
13	Georgia	0	1	-	-
17	Illinois	0.22	0.78	0.31	0.69
18	Indiana	0.49	0.51	0.81	0.19
19	Iowa	0	1	1	0
20	Kansas	0.01	0.99	0.53	0.47
21	Kentucky	0.52	0.48	0.3	0.7
22	Louisiana	0.24	0.76	1	0
23	Maine	0	1	-	-
24	Maryland	0.11	0.89	0.26	0.74
25	Massachusetts	0	1	-	-
26	Michigan	0	1	-	-
27	Minnesota	0	1	-	-
28	Mississippi	0.23	0.77	1	0
29	Missouri	0.01	0.99	0.65	0.35
30	Montana	0.95	0.05	0.34	0.66
31	Nebraska	0	1	-	-
32	Nevada	0	1	-	-
33	New Hampshire	0	1	-	-
34	New Jersey	0	1	-	-
35	New Mexico	1	0	0.63	0.37
36	New York	0	1	-	-

37	North Carolina	0	1	-	-
38	North Dakota	0.98	0.02	0.98	0.02
39	Ohio	0.65	0.35	0.38	0.62
40	Oklahoma	0.02	0.98	0.95	0.05
41	Oregon	0	1	-	-
42	Pennsylvania	0.68	0.32	0.57	0.43
44	Rhode Island	0	1	-	-
45	South Carolina	0	1	-	-
46	South Dakota	0	1	-	-
47	Tennessee	0.03	0.97	0.33	0.67
48	Texas	0.48	0.52	1	0
49	Utah	0.87	0.13	0.76	0.24
51	Virginia	0.5	0.5	0.32	0.68
53	Washington	0.55	0.45	-	-
54	West Virginia	0.55	0.45	0.34	0.66
55	Wisconsin	0	1	-	-
56	Wyoming	1	0	0.08	0.92

Table 3: Effect of Political Boundaries on Probability of Trade

	(1)	(2)	(3)	(4)
Different State	-0.0027*** (0.0004)	-0.0033*** (0.0004)	-0.0039*** (0.0005)	-0.0020*** (0.0003)
Different County	-0.0170*** (0.0039)	-0.0191*** (0.0043)	-0.0265*** (0.0056)	-0.0045 * (0.0026)
Different Congress	-0.0020*** (0.0004)	-0.0020*** (0.0005)	-0.0035*** (0.0006)	-0.0005 (0.0003)
Total Mine Production	0.0001*** (0.0000)	0.0001*** (0.0000)	0.0001*** (0.0000)	0.00004 *** (0.0000)
Total Plant Purchases	0.0002*** (0.0000)	0.0003*** (0.0000)	0.0003*** (0.0000)	0.0001 *** (0.0000)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bins
Year FE	X	X	X	X
Plant Location Control	X	X	X	X
Average Frequency of Any Trade	0.020	0.020	0.020	0.02

Note: *: < 0.01, **: <0.05, *: <0.10. Standard errors are clustered at the plant-mine-level. See Equation 1.**

Table 4: Effect of Political Boundary on Quantity of Coal Traded (Millions of Tons)

	(1)	(2)	(3)	(4)
Different State	-0.0086** (0.0035)	-0.0124*** (0.0035)	-0.0068* (0.0035)	-0.0004 (0.0061)
Different County	-1.3907*** (0.2108)	-1.3955*** (0.2106)	-1.3908*** (0.2107)	-1.5601*** (0.4681)
Different Congress	-0.0950*** (0.0228)	-0.1000*** (0.0208)	-0.0932*** (0.0209)	-0.0403 (0.0276)
Total Mine Production	0.0045*** (0.0003)	0.0025*** (0.0002)	0.0025*** (0.0002)	0.002*** (0.0003)
Total Plant Purchases	0.0046*** (0.0001)	0.0047*** (0.0006)	0.0047*** (0.0006)	0.0047*** (0.0008)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bins
Year FE	X	X	X	X
Plant Location Control	X	X	X	X
Average Quantity (Millions of Tons)	0.010	0.010	0.010	0.010

Note: *: < 0.01, **: <0.05, *: <0.10. Standard errors are clustered at the plant-mine-level. See Equation 2.**

Table 5: Effect of Political Boundary on Coal Quantity Traded Given a Trade Occurred (Millions of Tons)

	(1)	(2)	(3)	(4)
Different State	-0.0022 (0.0339)	-0.0003 (0.0339)	-0.0052 (0.0333)	0.1215* (0.0674)
Different County	-1.0474*** (0.1849)	-1.034*** (0.1859)	-1.0528*** (0.1849)	-0.9424** (0.4506)
Different Congress	-0.0816 (0.069)	-0.0645 (0.0674)	-0.1012 (0.0654)	-0.0602 (0.1132)
Total Mine Production	0.0046*** (0.0004)	0.0046*** (0.0004)	0.0046*** (0.0004)	0.0043*** (0.0007)
Total Plant Purchases	0.2341*** (0.0197)	0.2345*** (0.0199)	0.2339*** (0.0199)	0.2167*** (0.029)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bins
Year FE	X	X	X	X
Plant Location Control	X	X	X	X
Average Quantity (Millions of Tons)	0.526	0.526	0.526	0.526

Note: *: < 0.01, **: <0.05, *: <0.10. Standard errors are clustered at the plant-mine-level. See Equation 2.**

Table 6: Effect of Political Boundary on Probability of Trade (Regression Discontinuity with All Mines)

	(1)	(2)	(3)	(4)
Different State	-0.0381***	-0.0489***	-0.0359***	-0.0337***
	(0.0062)	(0.0062)	(0.0062)	(0.060)
Total Mine Production	0.0017***	0.0018***	0.0020***	0.0022***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Total Plant Purchases	0.0013***	0.0013***	0.0013***	0.0013***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bins
Year FE	X	X	X	X
Plant Location Control	X	X	X	X
Average Frequency of Any Trade	0.021	0.021	0.021	0.021

Note: *: < 0.01, **: <0.05, *: <0.10, Standard errors are clustered at the plant-mine-level. See Equation 3.**

Table 7: Effect of Political Boundary on Probability of Trade (Regression Discontinuity with Only In-State Mines)

	(1)	(2)	(3)	(4)
Different State	-0.0467***	-0.0483***	-0.0054***	-0.0453***
	(0.0091)	(0.0091)	(0.0092)	(0.0090)
Total Mine Production	0.0062***	0.0066***	0.0072***	0.0065***
	(0.0021)	(0.0021)	(0.0021)	(0.0021)
Total Plant Purchases	0.0007	0.0007	0.0007	0.0009
	(0.0005)	(0.0006)	(0.0006)	(0.0006)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bins
Year FE	X	X	X	X
Plant Location Control	X	X	X	X
Average Frequency of Any Trade	0.089	0.089	0.089	0.089

Note: *: < 0.01, **: <0.05, *: <0.10, Standard errors are clustered at the plant-mine-level. See Equation 3.**

Table 8: Effect of Political Boundaries on Transacted Price (Cents per MMBTU)

	(1)	(2)	(3)	(4)
Different State	-2.3187 (6.3526)	-2.2735 (6.3623)	-3.1584 (6.6)	0.2732 (6.1342)
Different County	12.9112** (6.3893)	13.7154** (6.0378)	15.4026** (6.3359)	3.9116 (6.3606)
Different Congress	0.27447 (5.9576)	0.96891 (6.0302)	2.6153 (6.062)	-1.4332 (4.9599)
Quantity (Millions of Tons)	-73.518*** (14.9040)	-73.6208*** (14.8002)	-73.9827*** (14.6578)	-73.7290*** (14.9981)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bins
Year FE	X	X	X	X
Mine FE	X	X	X	X
Average Price (Cents per MM BTU)	226.1	226.1	226.1	226.1
F-Test for Joint-Significance	1.4879 (p=0.21)	1.8976 (p=0.13)	2.2662* (p =0.078)	1.4762 (p=0.219)

Note: *: < 0.01, **: <0.05, *: <0.10, Standard errors are clustered at the plant-mine-level. See Equation 4.**

Table 9: Effect of Political Boundary on Contracting Decision

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Different Congress	-0.0239 (0.027)	-0.024 (0.0261)	-0.0266 (0.027)	-0.1992 (0.1961)				
Different County	-0.0351 (0.0274)	-0.0352 (0.0279)	-0.037 (0.027)	-0.6374 (0.4193)				
Different State	-0.0199 (0.0191)	-0.0199 (0.0193)	-0.0187 (0.0193)	-0.2906 (0.3201)	-0.0289* (0.0175)	-0.0346* (0.0181)	-.02907* (0.0172)	-0.3188* (0.1740)
Quantity	1.4057*** (0.1615)	1.4058*** (0.1612)	1.4035*** (0.1628)	1.4488*** (1.984)	1.4188*** (0.1629)	1.4239*** (0.1619)	1.4211*** (0.1635)	14.473*** (1.9823)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bin	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bin
Year FE	X	X	X	X	X	X	X	X
Plant Location Control	X	X	X	X	X	X	X	X
Contracting Frequency	0.845	0.845	0.845	0.845	0.845	0.845	0.845	0.845
Jointly Different from Zero?	5.84 (p=0.119)	5.58 (p=0.134)	6.21 (p =0.102)	6.749 (p=0.080)				

Note: *: < 0.01, **: <0.05, *: <0.10. Standard errors are clustered at the plant-level. See Equation 5.**

Table 10: Effect of Political Boundary on Duration of Contract

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Different Congress	3.8777 (3.9216)	3.6729 (4.0485)	3.2607 (4.0862)	4.0058 (3.8313)				
Different County	-10.942* (6.5345)	-11.646* (6.5705)	-13.31* (6.9363)	-17.788** (8.3207)				
Different State	10.548*** (2.7912)	10.573*** (2.776)	10.907*** (2.7579)	10.344*** (2.6485)	10.961*** (3.115)	10.901*** (3.709)	10.934*** (3.083)	10.848*** (2.8808)
Quantity	34.68*** (11.102)	34.833*** (11.072)	34.643*** (11.04)	28.928*** (10.399)	36.913*** (10.67)	37.092*** (10.592)	37.244*** (10.582)	30.768*** (10.616)
Distance Control	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bin	4 Degree Polynomial	3 Degree Polynomial	Spline	10 mile bin
Year FE	X	X	X	X	X	X	X	X
Plant Location Control	X	X	X	X	X	X	X	X
Average Contract Length	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Jointly Different from Zero?	19.3*** (p=0.0002)	18.4*** (p= 0.0003)	21.2*** (p<0.0001)	20.747*** (p=0.0001)				

Note: *: < 0.01, **: <0.05, *: <0.10. Standard errors are clustered at the plant-level. See Equation 6.**

Table 11: Effect of Intra-Jurisdictional Mines on Power Plant Siting at County Level

	No Plant	Coal Plant	Non-Coal Plants Only
Mine in State	0.0097*** (0.0015)	-0.0011** (0.0005)	-0.0008*** (0.0002)
Mine in County	-0.0030 (0.0045)	0.0054*** (0.0016)	-0.0023 (0.0048)
Population	$-1.28\text{x}10^{-6}$ *** ($1.12\text{x}10^{-7}$)	$1.62\text{x}10\wedge^{-7}$*** ($2.08\text{x}10^{-8}$)	$1.12\text{x}10^{-6}$*** ($9.78\text{x}10^{-8}$)
Distance to Closest Coal Mine	0.0065*** (0.002)	-0.0129*** (0.00029)	0.0063*** (0.00019)

Note: *: < 0.01, **: <0.05, *: <0.10.**

Table 12: Effect of Intra-Jurisdictional Mine on Plant Closure

	(1)
Mine in State	-0.0696** (0.0296)
Nameplate Capacity	-0.0004*** (0.0000)
Opening Year	-0.0006*** (0.0000)
Distance to Closest Coal Mine	-0.0001 (0.0001)

Note: *: < 0.01, **: <0.05, *: <0.10. Standard errors are White-Robust. See Equation 7.**

Table 13: Effect of Coal Consumption on Local Ambient Air Pollutant Concentrations

	SO2	PM10
State Coal Consumption	0.0770*** (0.0069)	0.1775* (0.0995)
Local Coal Consumption	0.0224 (0.0453)	-0.9067** (0.0459)
Neighboring Coal Consumption	0.00007 (0.0037)	-0.0222 (0.0372)
Year FE	X	X
County FE	X	X

Note: *: < 0.01, **: <0.05, *: <0.10. See Equation 8.**

Table 14: Effect of in-state mines on NERC-level emissions

	CO2	SO2	NOX
Percentage of Plants with In-State Mine	2.264*** (0.0318)	0.0014** (0.0004)	0.0029*** (0.0001)
Coal Percentage of Capacity	26.607 (129.584)	-0.8810 (1.715)	-0.0784 (0.405)
Year FE	X	X	X
NERC FE	X	X	X

Note: *: < 0.01, **: <0.05, *: <0.10. . CO2, SO2, and NOX are expressed in millions of tons. See Equation 9.**

Figure 1: Power Plant Purchases and Mine Sales in 2014

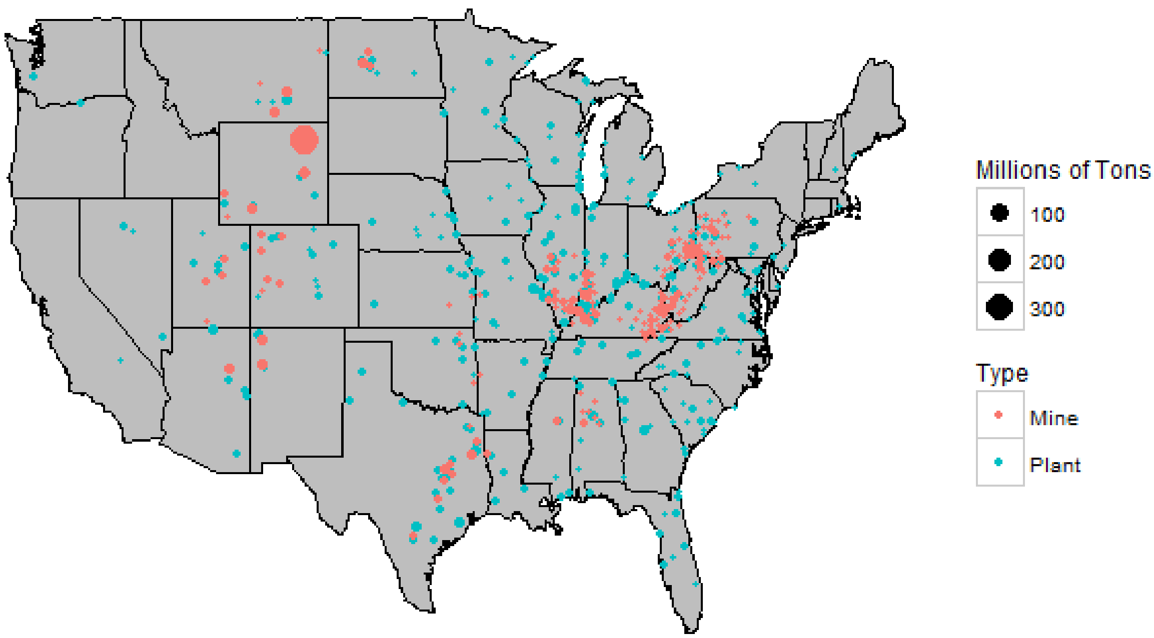

Figure 2: Power Plants Used in Our Regression Discontinuity Research Design

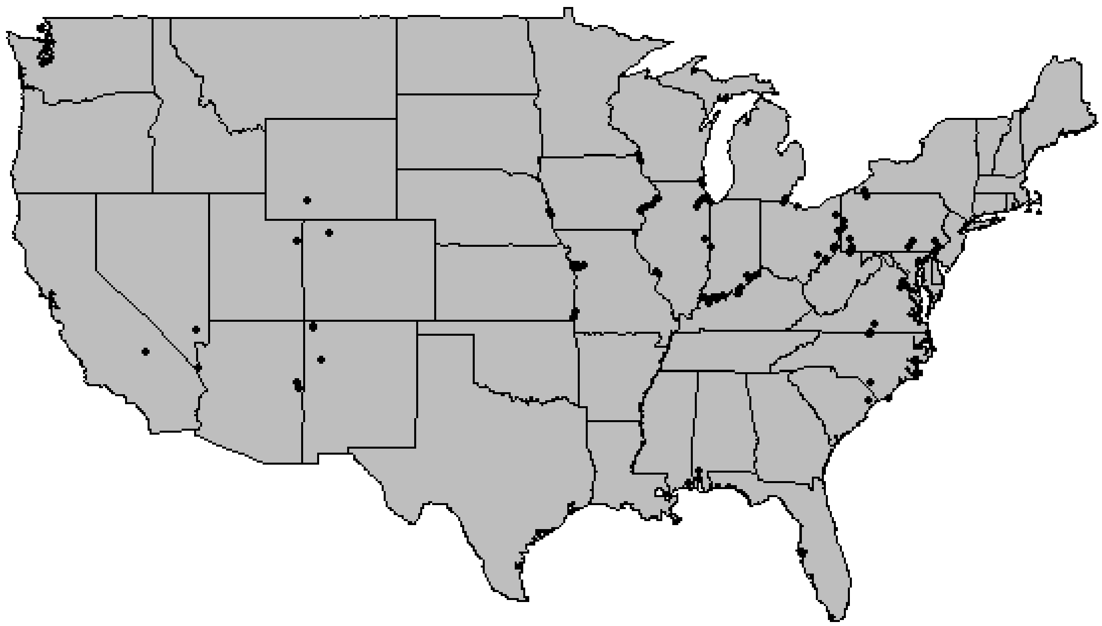

Figure 3: The Geography of Power Plants and Mines in Indiana, Ohio, West Virginia, and Kentucky

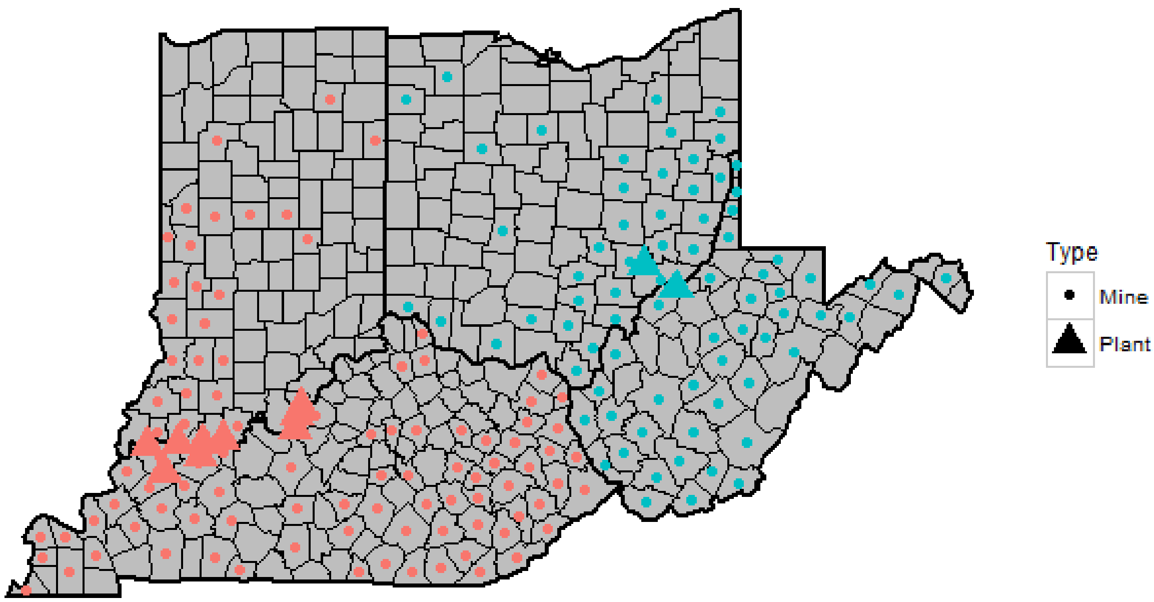

Figure 4: Different State Coefficient Over Time

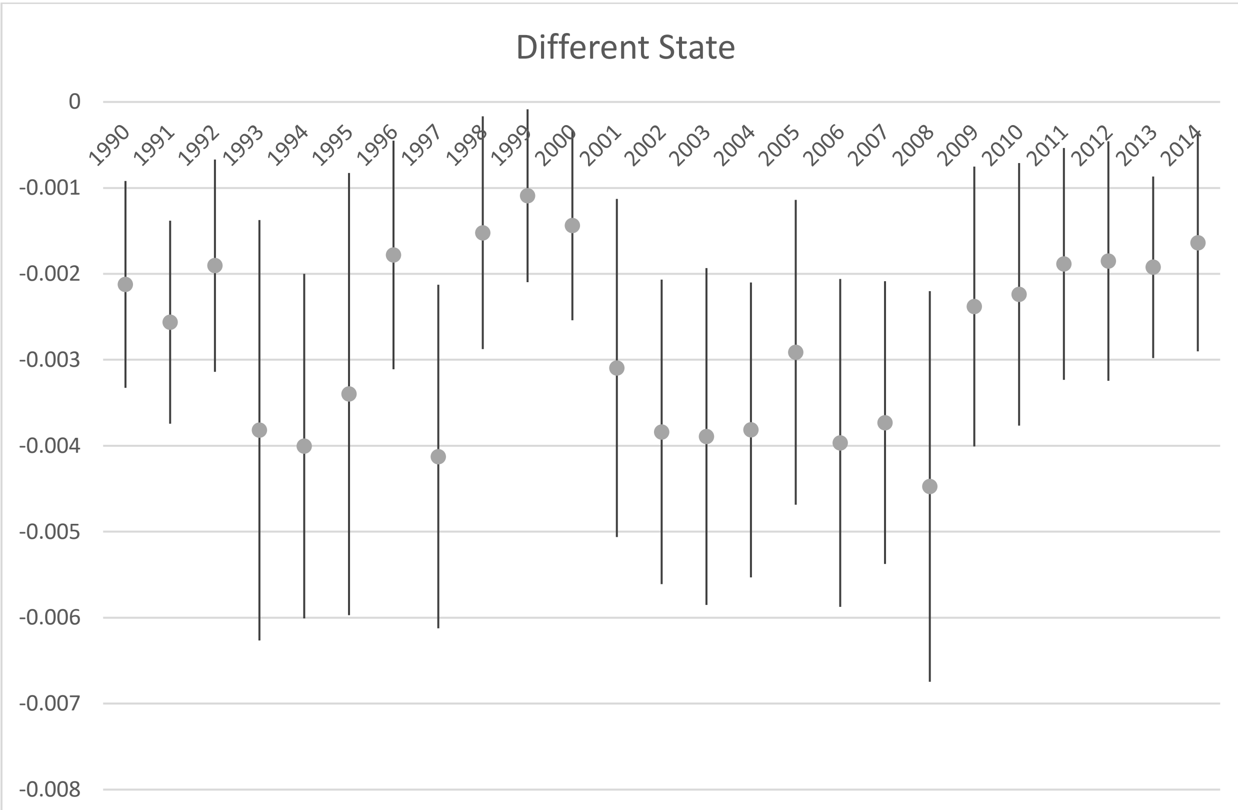

Figure 5: Different County Coefficient Over Time

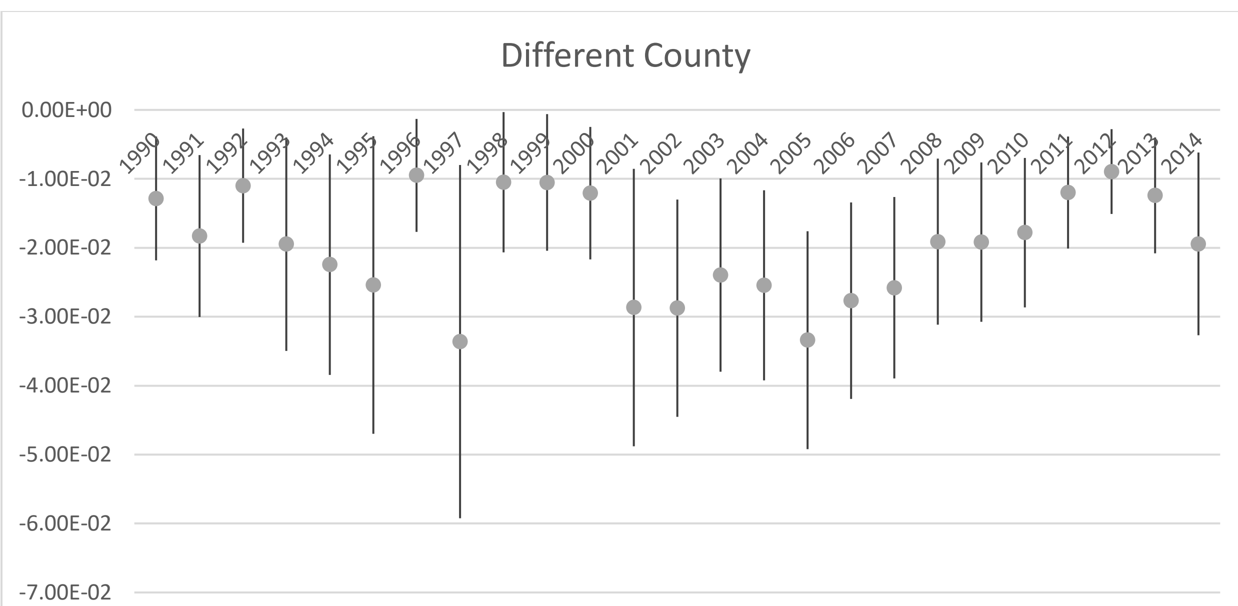

Figure 6: Different Congress Coefficient Over Time