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## Contract renegotiation and rent re-distribution: Who gets raked over the coals? ☆

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### ABSTRACT

Policy shocks affect the rent distribution in long-term contracts, which can lead to such contracts being renegotiated. We seek an understanding of what aspects of contract design, in the face of a substantial policy shock, affect the propensity to renegotiate. We test our hypotheses using data on U.S. coal contracts after the policy shock of the 1990 Clean Air Act Amendments. Contracts are divided into two categories, those that were renegotiated following the shock and those that were not. Characteristics of the contract are used to explain whether or not the contract was ultimately renegotiated. Results provide guidance on rent re-distribution and contract renegotiation more generally and are applicable to contemporary policy issues such as climate change legislation.

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### 1. Introduction

New policy initiatives have the ability to substantially shift rents within an economy. As a result, entities which previously made investments tied to the initial state of affairs (for example capital developments, or long-term purchasing contracts) will be affected by any proposed changes in regulatory policy. To date, there is a lack of empirical evidence concerning how these stakeholders contractually respond to the imposition of a change in regulatory policy. Policymakers are left without a rigorous evaluation of the impact of their proposals on stakeholders' rents, compared to the claims put forward. This paper attempts to address this void by investigating how long-term contracts for coal delivery in the electricity generation industry responded to passage of the 1990 Clean Air Act Amendments (CAAA).

The 1990 CAAA limited the emissions of sulfur dioxide, a by-product of coal combustion. The coal contracts then in existence allowed a range of sulfur content to be delivered in satisfaction of the contract terms. If a plant had allowed the mine a large degree of flexibility in the sulfur content of coal delivered, passage of the 1990 CAAA might have induced the plant owner to attempt to renegotiate the contract, to avoid the possible delivery of high-sulfur coal.

Contracts were flexible in other ways as well, such as through the pricing mechanism or minimum quantity transacted provisions. Such flexibility was not uniform, however, and many contracts ended up having to be renegotiated. Our

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ultimate empirical task is to seek an understanding of what factors in the initial contract design made more or less likely this renegotiation decision. More broadly, within the contextual example of coal contracts, we seek an understanding of what aspects of contract design affect the propensity to renegotiate when a policy shock (such as new legislation) occurs in the midst of a long-term contracting environment.

We ground our empirical model in the theory of long-term contracts as first postulated by Coase [3]. In *The Nature of the Firm*, Coase effectively argued that long-term contracts emerge in a world of transaction costs. Later authors [30,17,9] operationalized these ideas by identifying important categories of transaction costs, including uncertainty and asset specificity. How these transaction cost based issues are dealt with in any given contract determines the degree of flexibility the contract essentially embodies. Our hypothesis is that when an outside shock occurs in the midst of a contracting environment, the more flexible the initial terms of the contract, the lower the probability of explicit contract renegotiation in response to the outside shock.

In our empirical context, we measure the degree of flexibility embodied in a contract with certain contract characteristics, such as the price adjustment mechanism and the number of years until the contract expires. Results generally match expectations. Contracts with a larger minimum quantity and more years till expiration are more likely to be renegotiated. A higher allowable sulfur content upper bound also leads to a higher probability of renegotiation for plants that will be affected by the strictures of the 1990 CAAA.

From a policy perspective, this paper contributes to the literature in at least two ways. First, many governments have or are debating the adoption of greenhouse gas policy that plants could comply with by switching coal types, as was common for compliance with the 1990 CAAA.<sup>1</sup> Much of the discussion in the EU and US surrounds how firms will be compensated in any such climate legislation. Schemes that involve a cap-and-trade proposal with grandfathering as a permit allocation mechanism for electric utilities have been portrayed as embodying a windfall to utility companies. If, however, due to the legislation, the utility companies have to renegotiate their contracts for fossil fuel inputs, this windfall may actually be accrued by other players in the industry down the line. This historical look back at the effect of the 1990 CAAA on long-term fuel contracts will help in looking forward to the future effects of carbon emissions legislation today.

Second, this research speaks to the question of whether the efficiency of the 1990 CAAA was restricted by long-term contracting in the coal market. Swinton [27], Carlson et al. [2], and Sotkiewicz and Holt [26] have all suggested that the full cost savings potential of the tradable permit system in the 1990 CAAA was not achieved because inflexible, long-term contracts inhibited adjustment to the new state of affairs. This paper provides the first empirical evidence that is not consistent with this claim.

## 2. Background and literature review

Coal for use in the U.S. electricity industry is primarily procured through long-term contract. Spot markets account for only around 15% of total sales. The average duration of contracts, however, has been declining from around 14 years in the early 1980s to an average of 8 years in the 1990s [18]. Contracts are generally between a mine, a coal-fired power plant, and a transportation firm (often a railroad). Joskow [12] provides a detailed overview of contracts in the coal industry and notes that a mine and a power plant usually rely on long-term contracts that are incomplete but quite complex. Such contracts will contain both price and non-price provisions, such as a specified price adjustment mechanism, re-opener clauses at regular intervals, minimum quantity, and coal attribute provisions. Joskow [13,14] attempts to determine how contracts protect against *ex-post* changes to market conditions and what renegotiation, if any, is done when market conditions change. He finds that when the price of coal dropped after 1982, coal contracts were still largely adhered to, despite the downturn in prices. Though most contracts have *force majeure* provisions, the mine and plant generally abide by contractual obligations rather than to terminate, breach, or litigate a contract. When contracts are renegotiated, compromises are often made; prices fall but minimum quantity provisions at the same time increase.

The early literature on contract design was spearheaded by Coase [3], Klein et al. [17], and Williamson [31]. These papers laid out the theory that it is the existence of transaction costs which leads to vertical integration between exchange parties. The degree of vertical integration can range from simple contracts, to complex mergers, all the way up to regulation and/or government takeover of the transacting environment [9], but ultimately integration is a response to the hold-up problem.

The hold-up problem occurs when one firm makes an investment whose value is largely determined through the use of another firm's product and subsequently finds that the other firm tries to expropriate the rents generated by a relationship specific investment. Three important categories of transaction costs have been identified in the literature: the uncertainty/complexity of the contracting environment, the time duration of the exchange relationship, and the degree of investment by either party in relationship-specific assets, such as boilers that are more efficient with certain types of coal.<sup>2</sup>

Predictions of transaction cost theory are that as uncertainty, duration of an exchange relationship, or degree of relationship-specific investments increase, vertical integration of some form should increase as well. The problem with vertical integration as embodied in contracts, however, is that contracts can never be completely specified. This inability to

<sup>1</sup> Carbon dioxide emissions per million Btu vary by 5–15% [23,32], which is relevant given the proposed emissions limits.

<sup>2</sup> Williamson [31] later identified a fourth type of transaction cost, probity, but it is primarily related to governmental (not private-sector) contracts.

write complete contracts leads to other testable hypotheses of transaction cost theory, such as that as uncertainty or duration increase, contracts should become more relational or flexible in character, and that as investments increase, contracts should become less flexible, or, longer in duration.

Over the years a number of empirical tests have been conducted which confirm these broad predictions of transaction cost theory. Crocker and Masten [4,5], Neumann and von Hirschhausen [21], and Mulherin [20] all investigated natural gas contract terms in the context of transaction cost theory and found, for example, that the longer the duration of the exchange relationship the more flexible the pricing arrangements, and that with higher degrees of asset specificity, contracts embody longer durations. Other empirical confirmations of transaction cost theory include Crocker and Reynolds [6], using U.S. Air Force engine procurement contracts, and Gil [8] using movie industry contracts in Spain.

More recently, a theoretical literature has developed arguing that the inefficiencies inherent in the hold-up problem of long-term contract design can be eliminated through optimal contract provisions including, for example, renegotiation provisions [1,11] or options clauses [24,22]. It is an interesting discussion which, to date, lacks empirical tests. The only empirical model of the renegotiation decision in the literature can be found in Guasch et al. [10], and it is a test of the determinants of renegotiation provisions, rather than whether or not they lead to optimality of contract design. As such, however, it is a research effort similar in spirit to our own. It is an empirical analysis of concession contracts in Latin America in the transport and water sectors and it finds that contract clauses do significantly matter to the renegotiation decision. Specifically, they find that more flexible pricing schemes lead to a lower probability of later renegotiation. Overall, there is a need for more empirical testing of these ideas in the literature.

This analysis uses the 1990 CAAA as the policy shock which leads parties to consider contract renegotiation.<sup>3</sup> Regulation of coal-fired power plants is critical to controlling emissions of sulfur dioxide ( $\text{SO}_2$ ), as approximately 66% of all emissions come from coal-fired power plants [28]. Sulfur dioxide is formed when the sulfur inherent in the coal combines with oxygen in the combustion process. The concern at the time was over the acidification of water sources (acid rain) from the sulfur dioxide emissions. U.S. federal regulation of sulfur dioxide emissions from coal-fired boilers began with the 1970 Clean Air Act, under which a vintage differentiated emission standard was employed. Existing boilers were regulated by the states while new boilers were federally regulated. States generally had much more generous standards than the federal government, which led to increased use of existing boilers and as a result a slower reduction in sulfur dioxide emissions than policymakers had hoped for.

During the 1980s various sulfur dioxide control bills appeared before Congress, but with little success. The politics of the problem made it difficult for most potential policies to proceed [7]. George H.W. Bush discussed an interest in using the market to regulate sulfur dioxide emissions during the presidential campaign in 1988. The Bush administration introduced its proposal in June of 1989. In November of 1990, the CAAA were signed into law. The 1990 CAAA, through Title IV, initiated a system of tradable permits for  $\text{SO}_2$  emissions in two phases that apply to most coal-burning power plants in the U.S.<sup>4</sup> All of the Phase I boilers affected had previously been unregulated, at least at the federal level, and generally burned high sulfur coal and emitted large amounts of  $\text{SO}_2$ . Even though the federal government was taking control of  $\text{SO}_2$  regulations, state governments could alter how boilers complied through incentives in economic regulation [19].

By almost every measure, Title IV has been a success. Carlson et al. [2] estimates a savings of around \$250 million annually from Phase I and Ellerman et al. [7] estimates a \$360 million annual savings. However, some studies suggest that there may be more savings available. Swinton [27], Carlson et al. [2], and Sotkiewicz and Holt [26] use three different applied methods to determine that the potential cost savings of Title IV is larger than the actual cost savings. All three papers speculate that the divergence between actual savings and potential savings could be due to the inability to alter long-term coal contracts. This work can shed light on the speculation that coal contracts prohibited the tradable permit scheme from reaching its cost savings potential. More broadly, this paper investigates the effect of the 1990 CAAA policy shock on the decision to renegotiate long-term coal contracts.

### 3. Theoretical model

We formulate our test of the renegotiation decision in long-term U.S. coal contracts around the following model.<sup>5</sup> Two firms, A (the seller) and B (the buyer), at some initial date (Period 0 in Fig. 1) enter into a contract to trade over a period of time a particular good,  $q$ .  $q$  is dependent upon a number of characteristics, as represented by the vector  $\mathbf{I}$ , including quality of the good and geographical location of the good, such that  $q(\mathbf{I})$ . In our context,  $q(\mathbf{I})$  is coal and  $\mathbf{I}$  represents factors such as sulfur content, Btu rate, and coal-mining region. The characteristics of  $q$  at delivery are not fully specified when the contract is signed in Period 0. Either due to technological or environmental constraints, it is assumed that it is not possible to completely specify at date 0 the  $q(\mathbf{I})$  to be delivered.

<sup>3</sup> Empirical work by Keohane and Busse [16] and Lange and Bellas [18] have already shown that initial rent distributions were affected by the 1990 CAAA.

<sup>4</sup> Phase I began in 1995 with the inclusion of approximately 263 boilers which were granted permits at a rate of 2.5 lbs of  $\text{SO}_2$  emitted per million Btu. Phase II began in 2000 and applied to essentially the entire population of coal-fired power plants in the US, which were granted permits at a rate of 1.2 lbs of  $\text{SO}_2$  emitted per million Btu.

<sup>5</sup> Notation loosely follows that used in Hart and Moore [11] and Noldeke and Schmidt [22].

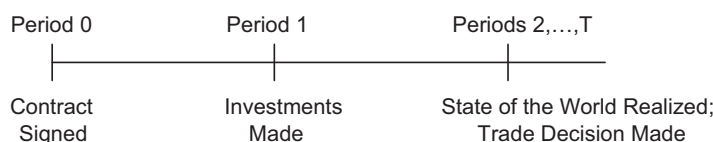


Fig. 1. Coal contract formation and implementation

After the contract is signed in Period 1, even though knowledge of future  $q(\mathbf{l})$  to be delivered remains incomplete, both the buyer and the seller make irreversible investments ( $\beta_A$  and  $\beta_B$ ) that allows them to carry out the contract in the remaining periods. A, for example, develops a coalfield and invests in the bulky capital equipment required to mine the coal; B invests in coal-burning plants that are specific to the quality and quantities of coal expected from A. Because the choices of  $\beta_A$  and  $\beta_B$  are dependent upon expectations of the characteristics  $\mathbf{l}$ , it is apparent that  $\beta_A(\mathbf{l})$  and  $\beta_B(\mathbf{l})$  are sufficiently complex that they too cannot be contracted on in period 0.  $\beta_A(\mathbf{l})$  and  $\beta_B(\mathbf{l})$  are, however, determined in Period 1, and so they entail a degree of commitment between the buyer and the seller that cannot be reversed in later periods ( $t > 1$ ) if either party changes their mind about delivery of  $q(\mathbf{l})$ . After period 1, A and B are now locked-in to each other because of these committed investments whose resale value is assumed to be less than their value in their intended usages. This, in essence, represents the hold-up problem inherent in long-term contract design.

In Periods 2, ..., T, the state of the world,  $\omega$ , is realized and trade of  $q(\mathbf{l})$  is executed under the terms of the contract. The vector  $\omega$  represents exogenous factors to the trading environment, such as new demand preferences, weather effects, or, of most relevance to this paper, policy shocks.  $\omega$  is publicly observable in each period 2, ..., T though sufficiently uncertain that it cannot be contracted on in Period 0. The goal of both firms is to maximize profits  $\pi_A$  and  $\pi_B$  in each subsequent period, from the fruition of the contract, A by selling  $q(\mathbf{l})$  as profitably as possible, B by buying  $q(\mathbf{l})$  as cheaply as possible.<sup>6</sup> The ultimate profit realized by each firm in Periods 2, ..., T depends on the contracting environment, specifically, on the investments made  $\{\beta_A(\mathbf{l})$  and  $\beta_B(\mathbf{l})\}$ , on the quality of the coal available  $\{q(\mathbf{l})\}$ , and on the specific state of the world,  $\omega$ , realized in each period 2, ..., T:

$$\pi_A[q(\mathbf{l}), b_A(\mathbf{l}), \omega]$$

$$\pi_B[q(\mathbf{l}), b_B(\mathbf{l}), \omega]$$

It is impossible, in Period 0, to write a contract completely specified over every outcome state possible for  $q(\mathbf{l})$ ,  $\beta_A(\mathbf{l})$ ,  $\beta_B(\mathbf{l})$ , and  $\omega$ . This is the tradeoff of transaction cost theory. Contracts can either be made cheap and incomplete, and therefore flexible to future circumstances, or expensive and thorough, and therefore more rigid (and certain) in response to future circumstances, but either way, all contracts are incomplete. When the ultimate values of  $q(\mathbf{l})$ ,  $\beta_A(\mathbf{l})$ ,  $\beta_B(\mathbf{l})$ , and  $\omega$  are realized in Periods 2, ..., T, profits ( $\pi_A$ ,  $\pi_B$ ) will be realized.

Any change in profit levels from period to period has the potential to lead to contract renegotiation.<sup>7</sup> If the status-quo has been disrupted and gains from trade upended, firms may feel that the current contract is no longer serving their interests. In such an instance, firms can either continue with the contract and absorb any profit level changes as a result of the changed environment, or they can seek to explicitly renegotiate the contract in order to address the new environment.<sup>8</sup> When does a change in profit levels lead to explicit renegotiation? What we investigate in this paper specifically, is the effect of an exogenous policy shock (in other words, a change in  $\omega$ ) to the contracting environment that affects the profit levels of the firms, disrupting equilibrium and having the potential to lead to contract renegotiation.

Our hypothesis is that if the profit changes resulting from the new state of the world ( $\partial\pi_{A,B}/\partial\omega$ ) can be balanced by coal characteristic delivery changes ( $\partial\pi_{A,B}/\partial l$ ) such that  $(\partial\pi_{A,B}/\partial\omega) + (\partial\pi_{A,B}/\partial l) = \varepsilon$  close to 0, equilibrium is maintained and the contract will not devolve into renegotiation proceedings. If, however, the contract is inflexibly written so that  $(\partial\pi_{A,B}/\partial\omega)$  (and its potential related effects such as on contract duration) cannot be balanced by  $(\partial\pi_{A,B}/\partial l)$  changes, the empirical hypothesis which we test below and which is predicted in transaction cost theory is that the inflexibly written contracts will be more likely to devolve into renegotiation. In other words,

**Hypothesis.** *The smaller (greater) the distributions of the coal characteristics,  $\mathbf{l}$ , (implying a more limited (expensive), inflexible (flexible) contract), the greater (smaller) the probability of renegotiation when a shock occurs to the state of the world,  $\omega$ .*

#### 4. Data

Our empirical context is long term U.S. coal contracts. Data on these contracts were obtained from the Coal Transportation Rate Database (CTRB) which is maintained by the Energy Information Administration. The CTRB is a

<sup>6</sup> This is a partial-equilibrium analysis. The overall objective function of each of the firms, of course, is to maximize profits from their comprehensive operations, but it is still possible (and profitable) to analyze decision-making on this more parsimonious level.

<sup>7</sup> If there is no profit level change from one period to the next, we assume stationarity and that, therefore, neither party has an incentive to try and change the terms of the contract. See Joskow [14] for more discussion of incentives to renegotiate.

<sup>8</sup> Firms could also simply balk and walk away from the contract entirely, but in the coal industry this is rare. As Joskow [13,14] documents, long term coal contracting relationships tend to be important to both players, and even in the face of extreme shocks neither side tends to renege and walk away.

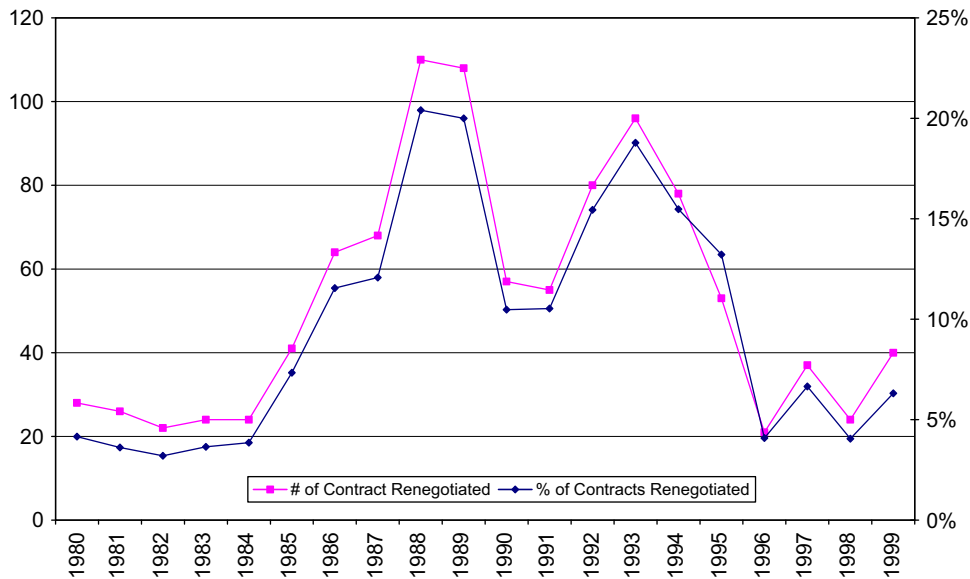


Fig. 2. Coal contract renegotiation over time.

survey of investor-owned, interstate electric utilities with steam-electric generating stations of more than 50 megawatts.<sup>9</sup> The dataset can be thought of as two separate data sources merged. The first set of information is on the contracts and the second is information on deliveries for each contract. The complete dataset contains information on coal transactions for the years 1979–1999, regardless of when the contract was signed. Information included are the type of contract, cost, quality, and origin of coal purchases as well as the lower and upper bounds for a number of coal attributes. Unfortunately, there is no information concerning re-opening or *force majeure* provisions.

The dataset codes each contract with a unique identification number. Each contract appears many times in the dataset as deliveries occur over time. With each delivery in the data, the year signed and year of last modification are given.<sup>10</sup> Modifications are evidence of explicit renegotiations in the contract. The number of renegotiations and percentage of contract renegotiated throughout the sample can be seen in Fig. 2. There are two spikes in the figure, one between 1986 and 1989 and another between 1992 and 1994. The spike in the early 1990s is likely to be a result of the CAAA and is the focus of this analysis. The spike previous to 1990 is at least partially the result of the fall in the real price of coal beginning in 1983, as argued in Joskow [14]. It is observed that the number of trade press articles concerning contract renegotiation increased considerably in 1985, 1986, and 1987, compared to earlier in the decade. An additional potential reason for the spike in the later 1980s is that plants and/or mines began to expect sulfur dioxide regulation legislation to likely succeed with the incoming Bush Administration, and altered their contracts accordingly. We address this interpretation in the empirical section below.

The information in the CTRB is used to determine the vintage of each contract, either the year signed if no modifications are specified, or the year of last modification. Contracts signed in 1991 or later are excluded from the analysis. Contracts with a vintage of 1990 or earlier but expiration before 1994 are excluded from the analysis since they would not need to be renegotiated given they expire before the 1990 CAAA are put into effect.<sup>11</sup> This leaves contracts with a vintage of 1990 or earlier that were still in effect in 1995. There are 272 contracts in the dataset that fit these restrictions. If any of these contracts had a vintage change to 1991 or later, they were considered renegotiated. The dependent variable for this analysis, *Renegotiated Contracts*, is binary and set to one if a contract is indeed renegotiated and zero otherwise.

The explanatory variables detail the parameters of the contract and the plant and mine involved. Perhaps the most important included variables relating to our policy shock of passage of the 1990 CAAA are *Allowable Sulfur Upper Bound* and *Phase I Plant*. *Allowable Sulfur Upper Bound* is a measure of the contracted coal's allowable sulfur content upper bound, in percent by weight. After passage of the 1990 CAAA, higher sulfur-content coal was markedly less valuable than lower sulfur-content coal. Contracts that allowed for delivery of higher sulfur-content coal, then, became less valuable to the plant owner, although at the same time more valuable to the mine owner. It is difficult to predict a priori which direction the sign on this coefficient will go, as it will depend on the relative bargaining strength of the mine and plant owner, but

<sup>9</sup> Our final empirical analysis includes data from 146 distinct electricity plants from approximately 80 utilities.

<sup>10</sup> The data instructions do not define what a "modification" is, thus we cannot determine whether the modifications were large or small. A random sample of 30 contracts found that 11 of them had quantity changes, 5 had sulfur content changes, and 5 had no change in the information given.

<sup>11</sup> Though not analyzed here, the use of a 5 year lag between passage and implementation of the 1990 CAAA meant that 177 contracts from the dataset did not need to be renegotiated. Clearly longer lags imply less need for renegotiation as the contracts expire before implementation.



according to transaction cost theory, greater contract flexibility should imply reduced contract renegotiation and since a higher sulfur upper bound implies a wider distributional range, we predict that in the aggregate, the coefficient on this variable should be negative.<sup>12</sup>

*Phase I Plant* is a dummy variable that takes a one if any of the boilers at a plant are subject to Phase I of Title IV of the 1990 CAAA. Plants that are affected by the regulatory shock of the 1990 CAAA are expected to be more likely to renegotiate their contracts. To distinguish between the effect of the allowable sulfur content upper bound on plants with Phase I boilers, and plants without, an interaction term is created, *Phase I\*Allowable Sulfur*, which is the product of the allowable sulfur content upper bound and the Phase I dummy. It is expected that the interaction term will be positive as Phase I plants with a high allowable sulfur content upper bound will have the contract rent distribution most affected by Title IV.

A number of variables are used to proxy for the level of transaction costs between the parties.<sup>13</sup> The first relates to the physical distance between the parties. *Distance Apart* measures the total distance in hundreds of miles that the coal travels from mine to plant, and is used to proxy for the closeness of the relationship of the contracting parties. It is possible that contracting parties that are geographically closer may have developed a stronger trade relationship, making the contract more flexible, leading to less need to explicitly renegotiate. However, the closeness may also lead to reduced transactions costs which will allow the parties to negotiate more complete, inflexible terms as bargaining is less costly. The expected sign of distance apart is therefore ambiguous.

Four variables are created to proxy for the level of dedicated assets the contract implies for the plant and mine.<sup>14</sup> *Plant Dedicated Assets* are defined as the ratio of an individual contract quantity to the sum of the plant's contract quantity.<sup>15</sup> Similarly, *Mine Dedicated Assets* is the ratio of an individual contract quantity to the sum of the mine's contract quantity. Larger levels of dedicated assets imply more appropriable quasi-rent at stake in the transaction, which will lead to a less flexible contract [25]. Thus, larger levels of dedicated assets are expected to lead to increases in the probability of explicit renegotiation when faced with a policy shock. A small percentage of plants are located at the "mine's mouth." Minemouth plants, integrated as they are directly at the mining site, have less alternative suppliers than non-minemouth plants, implying more dedicated assets between the parties. A *Minemouth* dummy is created which equals one if the plant is located directly next to a mine. Because of the relatively large amount of dedicated assets, these contracts should be inflexible and the probability that they are renegotiated due to external policy shocks, higher. *Quantity* is the minimum quantity to be delivered by the contract during each transaction. Larger quantity contracts are associated with longer contracts, making them less flexible and more likely to be renegotiated.

All contracts have a mechanism that adjusts prices over time. The sample here contains five categories of them: fixed price, base price plus escalation for economic conditions, cost-plus, price tied to market, and price renegotiation at specific intervals. Base price plus escalation contracts have an escalation that is usually a function of some economic indices (i.e., union wages or Consumer Price Index). Cost-plus contracts promise to pay all suppliers' costs plus a fee presumably determined before the contract goes into effect. The first two mechanisms are more rigid than the last three, in that they pre-arrange how the price can adjust, instead of allowing flexibility into the adjustment. A dummy variable, *Rigid Price Adjustment*, was created equal to one for contracts that are in the first category, fixed price or base price plus escalation and is zero otherwise.<sup>16</sup> A more rigid price adjustment mechanism makes it more difficult to implicitly negotiate the contract, thus it is expected that a more rigid price adjustment mechanism is associated positively with renegotiation.

The *Relative Price* of the coal is calculated using data from the Federal Energy Regulatory Commission (FERC) Form 423 on coal supplied for the year 1990. The mean and standard deviation of the price for each Bureau of Mine's coal producing district is calculated and the contract price in 1990 was used to calculate a z-score ((price–mean)/standard deviation). Bureau of Mine Districts were created to help classify coal types, thus the coal within each area is quite similar in quality. A positive relative price implies the contract price is above the mean price in the District. The effect that a relatively high or low price has on the probability of renegotiation depends upon the relative bargaining powers of the two parties, thus the expected sign is ambiguous.

A *Years Till Expiration* variable is created by subtracting 1991 from the contract expiration year. This variable relates to the varying lengths of contracts; contracts in our sample have an expiration year that ranges from 1995 to 2027. We would expect that, according to transaction cost theory, longer contracts (i.e. those with a higher value for *Years Till Expiration*) would have a higher probability of renegotiation, because the more years till expiration, the longer the parties are subject to the new rent distribution.

<sup>12</sup> A specification where contracts with an allowable sulfur content upper bound above the rate of permits granted in Phase I (2.5 lbs of SO<sub>2</sub> emitted per million Btu) is set to one and below set to zero was also run with the same results in sign and significance as *Allowable Sulfur Upper Bound*.

<sup>13</sup> Estimations including other transaction cost variables, such as whether the plant and mine had previously signed a contract, whether the plant has a scrubber, whether the contract had been renegotiated prior to 1990, and whether the deliveries to the contract ever violated the sulfur, ash, moisture, or Btu allowable provisions were done. Their inclusion does not change the sign or significance of the results. Results are available by request from the authors.

<sup>14</sup> Dedicated assets are defined, as in Williamson [29], as investments made that would otherwise not have been made except the prospect of buying or selling a large amount of product.

<sup>15</sup> This method follows Kerkvliet and Shogren [15].

<sup>16</sup> Other specifications of the *Rigid Price Adjustment* variable, such as designating cost plus contracts as rigid or using an ordinal scale of rigidity, were run and the results tend to match those given in the results below.

**Table 1**  
Summary statistics.

Variable	Full sample		Unchanged contracts		Renegotiated contracts		Difference Mean
	N=272		N=175		N=97		
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	
Renegotiated contracts	0.36	0.48					
Duration	21.90	10.67					
Allowable sulfur upper bound	1.39	1.26	1.64	1.52	1.17	0.91	0.46***
Phase I plant	0.24	0.43	0.19	0.40	0.24	0.45	-0.05
Distance apart (1000 Miles)	0.41	0.44	0.36	0.43	0.59	0.56	-2.3***
Plant dedicated assets	0.37	0.34	0.30	0.46	0.31	0.46	-0.01
Mine dedicated assets	0.19	0.27	0.23	0.32	0.15	0.21	0.09**
Quantity (1000 tons)	1.15	1.30	1.10	1.20	1.37	1.47	-0.27
Minemouth plant	0.05	0.21	0.02	0.14	0.02	0.15	0.01
Rigid price adjustment	0.81	0.40	0.78	0.41	0.87	0.33	-0.10*
Relative price	0.29	1.53	0.32	1.57	0.17	1.43	0.16
Years till expiration from 1994	7.03	5.92	6.15	5.35	7.87	5.95	-1.68**
88–90 year signed	0.14	0.35	0.15	0.34	0.17	0.37	-0.02
85–87 year signed	0.14	0.34	0.15	0.36	0.12	0.31	0.02
Appalachian coal mine	0.49	0.50	0.48	0.50	0.48	0.50	6.10E-03
Interior coal mine	0.18	0.36	0.20	0.40	0.20	0.40	-4.10E-03
Western coal mine	0.31	0.48	0.31	0.46	0.31	0.46	-0.01

\*, \*\*, and \*\*\* indicate 10%, 5%, and 1% statistical significance, respectively.

**Table 2**  
Expected Signs.

Dependent variable: renegotiated 1991–1994 or not	Expected sign
Independent variable	
Allowable sulfur upper bound	-
Phase I plant	+
Phase I*Allowable sulfur	+
Distance apart	+
Plant dedicated assets	+
Mine dedicated assets	+
Minemouth plant	+
Quantity	+
Rigid price adjustment	+
Relative price	?
Years till expiration	+
88–90 year signed	?
85–87 year signed	?
Interior coal mine	?
Western coal mine	?

? = Ambiguous

Another set of explanatory variables groups the contracts either by their vintage or the year signed: *pre*-1985, 1985–1987, and 1988–1990. The vintage of the contract is calculated using either the year the contract was signed if it has not been renegotiated, or the year of the last renegotiation before 1991. There are no expectations as to how the different years signed or vintages of a contract will be associated with the probability of renegotiation.

Finally, dummy variables are created for each of the three coal-producing regions and nine plant regions. The coal producing regions are the *Appalachian*, *Interior*, and *Western* coal mine regions. The Western coal region has on average the lowest sulfur contents, followed by the Appalachian region and the Interior region. However, it is difficult to predict a priori which direction the sign on these region coefficients will go, as it will depend on the relative bargaining strength of the mine and plant owner. For example, plants with a contract with a Western region coal mine are likely to not want to renegotiate while the mine would want to renegotiate given the change in the value of sulfur after Title IV. The nine plant regions are by census division. Summary statistics for all of the variables are given in Tables 1 and 2 lists the expected effects of our explanatory variables on the probability of contract renegotiation.<sup>17</sup>

<sup>17</sup> Renegotiated and unchanged contracts are not statistically different in observable characteristics not included in the analysis such as the number of previous modifications, allowable ash upper bound, and allowable Btu lower bound.

**Table 3**  
Determinants of contract renegotiation.

Probit estimation-marginal effects	Full sample		Contracts signed pre-1988	
Dependent variable: renegotiated between 1991 and 1994 or not				
Variable	Estimate	Std. error	Estimate	Std. error
Allowable sulfur upper bound	−0.20***	0.05	−0.23**	0.05
Phase I plant	−0.18	0.11	−0.10	0.13
Phase I*Allowable sulfur	0.26***	0.07	0.28***	0.08
Distance apart (1000 Miles)	0.32***	0.08	0.37***	0.09
Plant dedicated assets	−0.08	0.12	−0.08	0.12
Mine dedicated assets	−0.18	0.15	−0.21	0.18
Minemouth plant	−0.11	0.18	−0.10	0.17
Quantity (1000 tons)	0.05*	0.03	0.05*	0.03
Rigid price adjustment	−0.01	0.1	0.11	0.08
Relative price	−0.05*	0.02	−0.05*	0.03
Years till expiration from 1994	0.01**	5.90E−03	0.02**	6.10E−03
88–90 year signed	−0.05	0.08		
85–87 year signed	−0.10	0.08	−0.10	0.07
Interior coal mine	0.20*	0.11	0.14	0.13
Western coal mine	−0.15	0.12	−0.27**	0.12
N	272		228	
R-Squared	0.21		0.28	

Plant region dummies included but not shown.

\*, \*\*, and \*\*\* indicate 10%, 5%, and 1% statistical significance, respectively.

## 5. Empirical model

The theoretical model discussed above argues that the likelihood of explicit renegotiation increases in the face of a policy shock when contracts have little inherent flexibility to absorb and balance the changed rent distributions. We do not observe the actual probability of renegotiation, only whether the contract was actually renegotiated. Thus we use an indicator variable,  $R_i$ , to proxy for the probability of renegotiation. We parameterize our theoretical model using a probit estimation of the following equation:

$$R_i = \alpha + \beta_1 L_i + \varepsilon_i \quad (1)$$

where  $R_i$  is an indicator variable taking the value of one if the contract was renegotiated and zero if it was not,  $L_i$  is a vector of variables relating to the coal contract characteristics, and  $\varepsilon_i$  is an error term. To determine whether the sample should be pooled or split by regions, each explanatory variable was interacted with the region dummy variables, and a Chi Squared-test was undertaken to discover if the explanatory variables are statistically equal across the three regions. The results (available by request) fail to reject the null that the interacted coefficients are jointly equal to zero. Thus the sample is pooled for the empirical model given in 1. Grouping the error terms by utility (i.e. the firms that own the power plants) or using the Sandwich estimator of variance does not change the statistical significance of the results. Two estimations are shown in Table 3. The first uses the entire sample and the second restricts the sample to those contract signed before 1988, to ensure exogeneity of the policy shock.

## 6. Results<sup>18</sup>

Table 3 provides the results of the probit estimation with the marginal effects reported instead of the estimation coefficients. Two regressions are presented, the first on the full sample, the second on a restricted sample without contracts signed between 1988 and 1990.<sup>19</sup> The second sample is estimated to ensure the exogeneity of the policy shock of passage of the 1990 CAAA. Given the pattern of renegotiations in Fig. 2 and the political timeline discussed above, it may have been that by 1988 the writing was on the wall and coal mines and generation companies could tell that sulfur dioxide emissions were soon to be regulated. The results between the two regressions are indeed remarkably similar. The only coefficients whose significance changes are the *Western* and *Interior Basin*.

These results are in contrast to our counterfactual policy environment test, presented in Table 4. In this regression only contracts in existence before 1984, which continued past 1987, are used in the analysis. The dependent variable is now

<sup>18</sup> It is important to emphasize that coal contracts are quite complex, which makes condensing the information on them into useful empirics difficult. In the process, some information is necessarily left out. Care has been taken in the following analysis, however, to control for important factors in the relationship between a plant owner and a mine owner.

<sup>19</sup> Other samples which remove contracts signed after 1987 or 1989 were also estimated. Results are equivalent for these samples as the ones shown in the text and are available from the authors by request.



**Table 4**  
Counterfactual policy shock test.

Probit estimation-marginal effects		Full sample
Dependent variable: renegotiated between 1984 and 1986 or not		
Variable	Estimate	Std. error
Allowable sulfur upper bound	−0.09**	0.03
Phase I plant	0.15	0.20
Phase I*Allowable sulfur	0.16	0.11
Distance apart (1000 Miles)	−0.35	0.80
Plant dedicated assets	0.31***	0.10
Mine dedicated assets	−0.60***	0.13
Minemouth plant	−0.03	0.14
Rigid price adjustment	−0.25**	0.08
Quantity (1000 tons)	0.07*	0.04
Relative price	−5.42E−03	0.02
Years till expiration	−0.002	0.01
83–84 year signed	0.06	0.11
Interior coal mine	0.02	0.09
Western coal mine	−0.06	0.13
N	277	
R-Squared	0.23	

Plant region dummies included but not shown.

\*, \*\*, and \*\*\* indicate 10%, 5%, and 1% statistical significance, respectively.

equal to one if the contract was renegotiated between 1984 and 1986, and zero otherwise. The years 1984–1986 correspond to no changes in the regulation of sulfur dioxide and thus provide a counterfactual policy environment to test our model. In the results presented in Table 4, two variables have the same sign and significance as the policy shock analysis, the *Allowable Sulfur Content Upper Bound* and *Quantity*. Importantly, the interaction between *Allowable Sulfur Content Upper Bound* and *Phase I* is statistically insignificant; different from the 1990 CAAA policy analysis.<sup>20</sup> The counterfactual policy environment results are different than the policy shock results, implying that the policy shock results may reasonably be attributable to the 1990 CAAA.<sup>21</sup>

Back to Table 3, in both samples, the *Allowable Sulfur Content Upper Bound* variable is, as predicted, associated with a lower probability of contract renegotiation. However, interaction of the *Allowable Sulfur Content Upper Bound* variable with plants that were part of *Phase I* led to a greater likelihood of contract renegotiation. This implies that Phase I plants whose contracts specified a wide range of allowable sulfur content in the coal are more likely to renegotiate than those that did not. This is an interesting result on the heterogeneous effects of the 1990 CAAA on plant types.

Some of the transaction costs variables drawn from the literature and discussed in the data section have the expected sign, and a few are statistically significant. Larger *Quantity* is statistically associated with a higher probability to renegotiate, as this leads to more appropriable quasi-rents, which lead to less flexible contracts and the need to renegotiate when a policy shock occurs. Longer *Distance Apart* is associated with a higher probability to renegotiate, giving support to the argument that more inflexible contracts are written when the parties are geographically close. The *Years Till Expiration* variable is positive and significant across the regressions indicating an increased probability of renegotiation the longer the duration of the contract. This is expected given that the parties would be subject to the new rent distribution for a longer period of time.

Surprisingly, the dedicated asset variables are insignificant across the two samples. One would assume that coal mines and generating plants both have large fixed costs and therefore substantial dedicated assets in their respective businesses, yet the coefficients on these variables are insignificant. It could be that these proxies are not very good, or it could be that the large fixed costs involved in coal mining and use – both industries with long histories – have by now and for the most part been recovered. There is less that is “dedicated” and more that has already been paid off and moved off the books.

Finally, the *Western Coal Mine* variable enters negatively and is statistically significant in the restricted sample, implying that contracts with Western coal mines before 1988 were less likely to be renegotiated compared to those with Appalachian coal mines. Given that the 1990 CAAA increased the value of the coal in the West, as it was low-sulfur, this

<sup>20</sup> To further investigate any distinction between the counterfactual and the policy environment, data from both were combined and a dummy variable was created for the counterfactual data (*Counterfactual*). This was then interacted with all the independent variables. Results show that *Counterfactual* interacted with *Allowable Sulfur Content Upper Bound* and *Phase I* is equal and opposite in sign to *Allowable Sulfur Content Upper Bound* and *Phase I* in the policy period, giving additional empirical evidence to the suggestion that the environments are indeed different. A Chi-squared test (not shown) with a null that the sum of the counterfactual *Allowable Sulfur Content Upper Bound* and *Phase I* and policy *Allowable Sulfur Content Upper Bound* and *Phase I* is zero cannot be rejected.

<sup>21</sup> Three variables that were not statistically significant in the policy shock analysis are statistically significant in the counterfactual analysis. This would seem to imply that contracts respond differently to a policy shock as compared to a market shock (the reduction in coal prices discussed above), a subject for future research.

**Table 5**  
Renegotiation effect on price.

Dependent variable: real price of coal		
Estimation: hedonic price difference-in-difference model	Difference-in-difference parameter	
Sample	Estimate	Std. error
All plants ( $N=3409$ )	-1.32	1.31
All Phase I plants ( $N=2992$ )	-1.77	1.17
Phase I plants with western mine contracts ( $N=348$ )	3.38	1.99
Phase I plants with interior mine contracts ( $N=813$ )	-2.03	1.28

Other explanatory variables: Btu, sulfur, ash, and moisture content; total distance; contract, year and mine district dummies. Errors clustered by utility.

result implies that the plants had more bargaining power than the mines. At the same time, the *Relative Price* variable is also negative and statistically significant, implying that contracts with high relative prices were also less likely to be renegotiated. This result favors the mine owner. These two results together, on Western Coal Mine and Relative Price, may indicate a deal between plant and mine owners to avoid explicit renegotiation. Low-sulfur coal continued to be delivered, but only where the relative price was high. Adding an interaction of these two terms to the analysis reveals that the sign is consistent with this story, though the coefficient is not statistically different than zero.

In order to further explore the possible validity of this kind of a pact, an analysis to determine how the price of coal changed for those contracts that were renegotiated is undertaken. This is important as it also speaks to the ultimate rent re-distribution winners and losers from the policy shock.<sup>22</sup>

A difference-in-difference hedonic price analysis was undertaken to determine how the price of coal changed after renegotiation.<sup>23</sup> Here the treatment is renegotiation of the contract. The difference-in-difference parameter reveals how the price of coal changed for contracts after renegotiation relative to contracts that were not renegotiated controlling for changes due to the 1990 CAAA and the coal attributes delivered in the transaction. If bargaining power was larger for the mines (plants), it is expected that renegotiation would lead to a higher (lower) price and thus the difference-in-difference parameter would reflect this. This was done first on all the full sample, but it was also done on subsets of the data, including: (1) for plants that contain at least one Phase I boiler, (2) for plants that contain at least one Phase I boiler and the Western (low-sulfur) coal mines, and (3) for plants that contain at least one Phase I boiler and the Interior (high-sulfur) coal mines.

Results of the difference-in-difference hedonic price analysis are given in Table 5.<sup>24</sup> None of the estimations reveal a statistically significant difference-in-difference coefficient; however the signs do match expectations. When looking at contracts with Western coal mines, the estimate is positive while the opposite is true for contracts with the Interior coal mines. This pattern follows from the expectations stated above and suggests that the outcome of any renegotiation, whether implicit or explicit, may be some sort of a low-sulfur/high price pact. Further research investigating the strategic bargaining behind these renegotiation deals would be enlightening.

## 7. Conclusions

New policy initiatives have the ability to substantially shift rents within an economy, especially with respect to long-term investments. This paper investigates how long-term contracts for coal delivery in the electricity generation industry responded to passage of the 1990 CAAA. The topic is contemporary as many countries are debating policies to reduce greenhouse gas emissions and their resulting impact on the distribution of income. The findings reveal little evidence that either party was “stuck” with the contract previously signed, as those we expect likely to want to renegotiate seem able to. Further, many studies speculate that cost savings for Title IV could have been larger if long-term coal contracts were able to adjust to the new regulation. We find that many contracts were flexible enough to be renegotiated so failure to achieve cost-savings potentials cannot obviously be blamed on the contracting environment.

The hypothesis tested here is that when an outside shock occurs in the midst of a contracting environment, the more flexible the initial terms of the contract, the better the parties are able to deal with the policy shock within the current contract environment and the less likely they are to renegotiate. A model is devised which reveals that a contracts' degree of flexibility provides an important balancing function, which affects the likelihood of renegotiation. Empirically, the degree of flexibility is measured with contract price adjustment mechanism, number of years until expiration, quantity contracted, and distance between the parties. A probit model is estimated which finds an association between the

<sup>22</sup> An argument that is made by utility companies in support of the financial need for initial permit allocations to be grandfathered, rather than auctioned off, is that the rents would accrue to the mines.

<sup>23</sup> For more information about the hedonic price model for coal contracts, see Lange and Bellas [18].

<sup>24</sup> Full results of the difference-in-difference estimation are available from the authors by request.

probability of renegotiation and contracts with more years till expiration, large quantity, larger total distance apart. Plants that were part of Phase I and have a higher allowable sulfur content upper bound are statistically more likely to renegotiate their contract. These results are not consistent with the argument that long-term coal contracts are a major reason that Phase I has not achieved its full potential cost savings. Additional research should be done investigating why this earlier permit trading scheme was not as cost-effective as it could have been, especially since similar permit trading schemes are actively being considered for use in carbon regulation today.

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