Regulation and Contract Design: The Impact of Relationship Specific Investment

Kanishka Kacker

Department of Agriculture and Resource Economics

University of Maryland, College Park

Abstract

Firms often specialize investments to the individual needs of their buyers or suppliers. Although valuable, specialization raises the risk of opportunistic behavior. Accordingly, parties will implement contractual arrangements to counter such behavior. Testing this prediction empirically is difficult, as investment decisions are endogenous in the choice of contract. To account for this, I analyze the impact of a key environmental regulation, the Clean Air Act Amendment of 1990, on procurement strategies of US utilities. The Amendment, I argue, imparted a shock to physical investments made by utilities, lowering their specialization. By design of the Amendment, this shock varied exogenously over power plants, allowing for a difference-in-differences model arguably free from the endogeneity of investment decisions. I find, in support of theory, that lower specialization leads to sign shorter term, fixed price contracts, a result robust to alternate definitions of the outcome variable, sample specification and other regulatory changes.

JEL Codes: D22, D23, L94

The quality of this paper has been consistently revised upward. For this, special acknowledgment goes toward Rob Williams, Anna Alberini and Peter Murrell for highly informative discussions; Erik Lichtenberg, many participants of the Environmental and Resource Economics Workshop at the University of Maryland, and at Camp Resources 2010 raised pertinent issues with the data and the industry. I would also like to thank Kabir Malik, Anand Murugesan, Tran Trang and Sneha Bakshi for many patient hours spent together in discussing this work. Special acknowledgment also goes to Carl Pasurka, Ian Lange for early discussions about the industry. Michael Mellish and Patricia Morris of the Energy Information Administration helped in explaining certain nuances of the data.

1 Introduction

Firms often specialize their investments to their suppliers or buyers[1]. Such relationship specific investments play a central role in modern theories of organization and contracts, particularly amongst the literature on transaction costs pioneered by Oliver Williamson (Williamson 1975, 1979, 1985, 1996).

Relationship specific investments, it is argued, raise the possibility of ex-post opportunism. Appropriate contractual safeguards, such as price adjustment clauses, longer terms, or take-or-pay provisions need to be put in place to guard against such behavior. Such safeguards, however, inevitably entail the sacrifice of high-powered incentives. As investments become more specific, the cost of ex-post opportunism overtakes the cost of poor incentives and a switch in contract choice takes place[2].

Empirical verification of this causal link is difficult, as investment decisions are endogenous to the choice of contract. Relationship-specific investment[3] can only be observed when parties choose to enter into that transaction. Due to the simultaneity that arises, it is difficult to rule out a third factor (such as managerial ability, size or bargaining power) that could affect both decisions. Parties may choose to make investments specific to each other, and if such selection is not

[1]To take an example, consider power plants built next to a coal mine (mine-mouth plants). Locating next to a coal mine assures the plant of a reliable source of coal, as well as reducing transportation costs, and may require modification of equipment to suit the type of coal available. Similarly, mining efforts may be directed to confirm to the technology employed by the plant.

[2]Much of the earlier literature (Willamson 1975, 1985) argued that contracts in their entirety are unable to guard against opportunistic behavior, and suggested vertical integration as a solution. Crocker and Masten (1991) contend such a view as far too simplistic, and argue that contracts can vary in their governance and incentive properties. Recent theoretical work has built on this notion (Gibbons 2005 WHAT IS THE PAGE NUMBER).

[3]Recently, the complexity of a transaction and the amount of ex-post adaptation have also been shown to be important (Bajari and Tadelis 2001, Forbes and Lederman 2009). I concentrate mainly on relationship-specific investment in this paper.

controlled for, a bias may result.

For these reasons, the role of relationship specific investments in guiding contract choice remains controversial. Chiappori and Salanie (2003) criticize the methodology of many of the studies that attempt to correlate investment specificity and contract or organizational choice, on the grounds that they do not control for the endogeneity of the investment decision. In a comprehensive review, Lafontaine and Slade (2007) also note the endogeneity problem inherent in many of these tests. David and Han (2005) carry out a meta-analysis of the empirical literature on transaction cost based explanations of organizational and contractual decisions. According to the their analysis, out of 107 tests relating to relationship specific investments, 39 find statistically insignificant effects[4]. There is, as yet, little work that attempts a solution to this problem.

I exploit a key environmental regulation - the Clean Air Act Amendment of 1990 - as an exogenous shock that, I argue in section 2.2, forces investment to become less specific as it encouraged flexibility in switching between alternate suppliers, lowering the risk of ex-post opportunistic behavior. Such a switch should result in shorter term, fixed price contracts[5].

The Amendment was structured in two phases. In its first phase, the Amendment targeted only a subset of coal-fired plants (Phase I plants), for whom limits on emissions would start to bind in 1995. Phase II would include all remaining plants and emission limits would start to bind in 2000. In addition, the influence of the Amendment in terms of encouraging switching between coals also varies by the location of the plants.

I use these two exogenous source of variation to define a difference-in-differences

[4]The cut-off criterion was the 5% level of significance. Shelankshi and Klein (1995), Macher and Richman (2008) provide overviews of the empirical literature on transaction cost economics.

[5]Section 2 contains a full explanation of the proposed causal mechanism.

model, which arguably avoids the endogeneity of investment decisions. Comparing Phase I to Phase II plants after the announcement of the Amendment but before Phase II begins, Phase I plants should alter their contracts while Phase II should not, *ceteris paribus*[6]. The resulting difference-in-difference model identifies the impact of relationship specific investment.

My main outcome variable is the pricing arrangement between US coal-fired power plants and their coal suppliers. I use data from 1980 to 2000, which provides sufficient time before and after the announcement of the policy to analyze its impact on plant procurement decisions. These arrangements switch from base price with escalation clause contracts ("escalator contracts" from hereon) to fixed price contracts (Figure 1)[7]. I also examine contract length in some detail. To assess the robustness of the results, I also study other contract terms to see if they were affected similarly.

Coal supply arrangements between power plants and coal mines are a very good candidate for studying the implications of relationship-specific investment, given the long lived, immobile nature of investments on both sides of the transaction. Paul Joskow (1987) and Kerkvliet and Shogren (2001) study cross-sections of such arrangements. While Joskow (1987) finds statistically significant effects as per predictions of the theory, Kerkvliet and Shogren (2001) find significant effects opposite to expectations for two proxies of dedicated assets[8]. Kozhevnikova and Lange (2009) study a panel of these contracts from 1980 to 2000, and while they

---

[6]Of course, everything else does not remain the same. Most notably, the 1981 Stagger Act that deregulated railroads could also play a role. Also, cross-plant variation may also be a factor influencing contractual choice. For these and other variables, I include appropriate controls.

[7]Years 1988 and 1989 are excluded as, in these years, no fixed price contracts were recorded, and there is a high likelihood of a discrepancy in the data.

[8]Dedicated assets are a particular type of relationship specific investment, that arise when either the buyer or supplier (or both) commit a large fraction of their capacity for use only by the other.

find results generally as per theoretical prediction, some of their variables are statistically insignificant.

None of these papers, however, concern themselves with the endogeneity of the investment decision. Possibly this is the reason for some of the conflicting results. In addition to controlling for endogenous investment decisions, I have detailed information as to the identity of the plant, which allows me to incorporate fixed effects at the level of the plant into the empirical framework. To the extent that there are factors operating at the level of the power plant that are invariant over time, I am able to control for any resulting omitted variable bias. Given the slow changing nature of the electricity and coal mining industry, such factors may be important[9]. Last, in contrast with the above studies which only study contract length, I focus on the nature of pricing arrangement as well as contract length.

I find that plants affected by the Amendment are more likely to sign fixed price contracts with their suppliers, with the probability increasing by between 0.61 to 0.64 standard deviations. In addition, the length of the contracts these plants choose are approximately between 20% to 27% lower. These results are robust to altered definitions of the dependent variable, altered definitions of the sample used, the influence of other possible confounding factors, and the impact of regulatory change[10]. Finally, my specification is never inconsistent in direction, always statisticially significant, and at least as large, if nor larger, in economic terms than most other proxies that attempt to measure the influence of relationship-specific investments. In the next section, I describe how the Amendment may affect contract structure. I then describe the empirical model, and present estimates of this

[9] Phase I plants are larger and older than Phase II plants. These factors may influence the decision to adopt fixed price contracts, but as they are time invariant their influence is accounted for by the fixed effect.

[10] I consider two policy changes: the deregulation of the railroads following the 1981 Staggers Act, and the possible impact of the deregulation of the electricity market.

model.

2 Relationship specific investment, Pricing Arrangements and the Clean Air Act Amendment of 1990

There is a basic trade-off inherent in the choice of pricing arrangement when a buyer and a supplier sign a contract for the delivery of a product, when specialized investments are put in place. The major implication of specialized investment is that it raises bargaining costs, as both the buyer and supplier face a far smaller number of alternate traders once such investment has been made. In effect, they face a bilateral monoply situation[11].

The shrinking of the market implies that suppliers may engage in opportunistic behavior, since the buyer cannot find alternate partners easily[12]. In this manner, although the investments raise the gain from trade, this very rise incentivises opportunistic behavior.

Consider the situation where an unanticipated event arises during contract execution[13]. There is a possibility that the supplier or buyer makes strategic representations of the true state of the world to appropriate part of the surplus, due both to the information asymmetry created as a result of the unexpected

[11] Such a realization is not new. Oliver Williamson (1975) notes that relationship-specific investments will create a costly haggling situation, which may be alleviated through the use of long-term contracts. Also, Victor Goldberg and John Erickson (1987: p 388-390) describe how relationship-specific investments make the cost of renegotiation higher.

[12] There is a mutuality here, as the supplier is also left with few alternate buyers. The act of specialization implicates both buyer and seller.

[13] Although contracting parties take a long term view of their trade, due to the condition of bounded rationality, their ability to forecast future events and have complete knowledge of the actions taken by the other party is limited. Thus, any contract the buyer and seller sign is unavoidably incomplete, making unanticipated events possible.

change and the bilateral monopoly they are engaged in[14]. Such representations are unlikely to be taken at face value, and a costly bargaining process is likely to result.

Absent any procedure to settle these bargains, such bargaining is going to involve both time and effort to settle. Both parties, therefore, have an incentive to seek contractual arrangements to ensure that the costs of bargaining are kept as low as possible[15].

One such contractual arrangement is the pricing structure of the contract. Consider the two extreme cases of fixed price contracts on the one hand and cost plus contracts on the other[16]. It is important to understand that neither contract type is "optimal". Both have deficiencies, and the relevant question is which deficiency is more important to address.

Fixed price contracts specify a price fixed in advance for the entirety of the contract. For this reason, they are cheaper to write, as there is less requirement to put in possibly complex provisions for the various sources of cost the supplier is exposed to[17]. Fixed price contracts are also known to carry high powered incentives for performance (Williamson 1985, Corts and Singh 2004). For these reasons, the

[14] Both conditions of information asymmetry and bilateral monopoly are important. If information asymmetry does not exist, buyers and sellers have equal (if incomplete) information and there will be minimal bargaining. This is possible, but unlikely, as most unanticipated events will affect, at first, either the buyer or supplier, and this creates the asymmetry of information. If a bilateral monopoly situation is not created, the buyer or supplier can easily turn to other buyers or suppliers, thus mitigating any efforts by their partner to expropriate the surplus created by the trade. Note well that information asymmetry is a particular condition of bounded rationality.

[15] Of course, if specialized investments are not required, no bilateral monopoly situation is created. Competition, both ex-ante and ex-post, acts as a restraint on opportunism, and for such purpose, is arguably more effective than contractual clauses.

[16] Many pricing or other organizational arrangements observed in practice are variants of these two extremes, which is why I am at first restricting attention to them (see Bajari and Tadelis 2001, Tadelis 2002).

[17] Of course, there may be a lengthy negotiation stage in fixing the price. Such negotiations are only going to be longer, and therefore more costly, with more complex pricing arrangements.

parties may prefer a fixed price contract. The possibility of costly bargaining[18], however, creates a problem for fixed price contracts as they fix all prices in advance and cannot, at least in terms of prices, adapt to any altered conditions.

One simple method of accounting for unanticipated, or non-contracted for, change is simply to pass on all costs incurred by the supplier to the buyer. The simplicity of the adjustment process in a cost plus contract makes it a cheap way to resolve disputes.

By rewarding the supplier for all costs incurred, however, a cost plus contract encourages the supplier to engage in possibly more costly production than might be required. In addition, as it is difficult to know what costs the supplier actually bears[19], there is also a risk that the supplier may be getting paid for not much more than creative accounting[20].

What alternative to a cost-plus contract may exist? Any feasible alternative must be able to meet the twin conditions of bounded rationality and opportunism, while minimizing the cost of bargaining. One possibility is vertical integration. Although integration is more flexible than any contractual provision, the incentives such an organizational change offers are just as bad, and probably worse, than those that a contract may provide.

Another alternative is to specify a method to adjust prices. Crocker and Masten (1991) discuss such adjustment mechanisms. They argue that frequently contracting parties will provide for procedures to redetermine prices in an adaptive manner. Contracting parties may agree ex-ante to agree to renegotiate, schedule a series of price increases ex-ante, or specify a formula by which the prices are to

[18]Due, for instance, to the presence of relationship-specific investments.

[19]Recall the condition of bounded rationality, which limits the extent to which a buyer may know about the suppliers' costs.

[20]A possible remedy is to install monitors, or monitoring equipment. Doing so, however, has costs.

be increased. Let us consider these in order.

Agreeing to renegotiate may be a preferable option given its flexibility, but it may not resolve bargaining cheaply. If information asymmetry is serious, and the costs of determining the true state of the world from individual claims are prohibitively high, agreeing to reneogitate does not go very far as a solution.

Scheduling price increases ex-ante is another way parties may choose to account for the bargaining process. It is difficult to imagine, however, that contracting parties will be able to correctly anticipate all future conditions and appropriately adjust payments[21].

Specifying a formula by which to fix prices appears the most likely candidate. For such contracts to be a feasible alternative to fixed price contracts, they need to address the twin conditions of bounded rationality and opportunistic behavior.

Bounded rationality is met if the price formula adjusts payments in line with ex-post changes in the cost of supply, whatever the source may be. That is, rather than try to predict all future events and guess the appropriate response (which may be a futile activity), the formula simply adjusts to these events whatever they may be, to the extent that such events impact costs. Opportunism is also restricted as the adjustment process avoids supplier claims of incurred cost, yet still accounts for input cost, by (for example) using prices in the relevant market[22] as a proxy for the actual price.

Although more efficient than cost plus contracts in terms of mitigating opportunistic behavior, there exists an incentive for the supplier to use more inputs than required, as compensation is based partly on input quantity[23]. The appropri-

[21] In essence, these are simply sequential fixed price contracts.

[22] Crocker and Masten (1991) argue that as a result of relationship specific investment and the bilateral monopoly that arises, the relevant market to turn toward has to be localized to similar transactions.

[23] Compared to a fixed price contract, the risk of opportunistic behavior under price specification is greater, although compared to an outright cost-plus contract, such risk is

ate choice of contract, therefore, revolves around the expected cost of bargaining, which in turn revolves around how relationship specific the assets are[24].

The data supports this argument. Fixed price contracts and escalator contracts are the two most commonly used contracts, with the sum of the two accounting for nearly 80% of all the contracts. Cost-plus contracts only account for 3.5% of all the data. Price renegotiation contracts are used, but only for 7% of the total observations. I do not find any use of ex-ante price schedules, although there is some use of contracts that tie prices to market conditions, but these only account for 1.38% of the entire data[25].

2.1 Fixed Price and Escalator contracts

Going by definitions provided by FERC, "Fixed price" contracts are contracts that define a single price to be paid to the seller over the life of the contract. "Base price with escalation clause", or escalator contracts, are defined as containing provisions for the "escalation of different components [of the price] as a function of changing economic conditions". What items escalate? How do they do so? What are these economic conditions?

I use Paul Joskow's investigation into the pricing structure of contracts (Joskow 1985)[26] as a way of understanding pricing provisions for escalator contracts. Such contracts break the overall price into the various components of cost, as follows.

For certain components relating to government regulation, tax changes, or "changes in contract/union work rules" the supplier is allowed to pass through

lower, as one margin of rent-seeking behavior is eliminated.

[24] To a degree, of course. There may well be other reasons, varying as per situational demands, for choosing a particular contract. To take an example, the complexity of any particular project (Bajari and Tadelis 2001).

[25] See Table 1. These figures are for the data described in Section 3.

[26] Paul Joskow examines 21 contracts in force.

costs. For other aspects of cost - labour, machinery, depreciation, profit - a forumla fixes the price to be paid. Labour costs are separated into different categories, and wage rates are "indexed"[27] to changes that are either specified by collective bargaining agreements applicable to the area the mine is located in or to the average wage rate actually paid at the mine. Further, in some of the contracts, all increases in labour costs were passed through. Costs for the raw materials and machinery ("materials and supplies") involved in the mining of coal are compensated for based on the relevant parts of the Wholesale Price Index.

The price setting followed tries to approximate costs incurred in coal mining, although it is not always as simple as allowing all costs to directly pass through[28]. To the extent that direct pass-through of costs is allowed, transaction prices will reflect both the input prices and the organization of the inputs used.

Even if pass-through of actual costs incurred is not allowed for some components of cost, they still adjust for the usage of inputs by their prices - which determines the cost function. The mining company pays for the use of inputs, and expects compensation from the utility based on what this use costs them. Since the mining company retains the right of control over the labour and the material capital employed in the mining of coal, one may expect that providing for the costs of these in the pricing arrangement has the effect of weakening incentives for performance[29].

---

[27]Joskow (1985) uses the term "indexed" for cases in which the wage component had a fixed weight in the price formula, and adjusted only for changes in prevailing wage rates. Further, the determination of what constitutes the average rate is specified under manning tables.

[28]Fully cost-plus contracts could be chosen but, as noted above, rarely are. Under cost-plus contracts the utility has the power to "question the reasonableness of cost incurred, to audit the mining company and to approve mining plans, capital expenditures and budgets". If doing so is costly, cost-plus contracts will not be chosen.

[29]Once again, in comparison to a fixed price contract.

2.2 Physical asset specificity and the Clean Air Act Amendment of 1990

For coal procurement in the US, one way relationship specific investments are made by utilities is in their choice of boiler technology[30]. Coal varies in its chemical properties depending on where it is mined. Boilers were built to match the type of coal contracted for. Such matching was more specialized in the case of coal that comes from the western part of the US[31], as this coal tended to be far more heterogenous in quality, and thus required specialized boilers to burn it[32].

The Clean Air Act Amendment of 1990 set limits on the amount of sulphur emissions power plants were allowed. The goal of the amendment was to reduce the amount of sulphur di-oxide (SO_2) emissions in the US by 10 million tons from the level that existed in 1980. Power plants were phased into the program in two stages. In the first stage, beginning in 1995, only emissions from the dirtiest plants - termed Phase I plants - were capped[33]. Caps on the emissions from the remaining power plants were to be imposed in the second stage, due to begin in 2000[34]. The total number of Phase I plants was 110.

To bring their power plants into compliance, electric utilities could either switch to coal with a low sulfur content[35] or install scrubbers in the smoke stacks which would remove SO_2 from the smoke emitted. Some utilities found the cheapest option was to switch to low sulphur coal, found in the western part of the US

[30] Power plants are made up of a number of generating units. A generating unit consists of a generator that converts mechanical energy into electricity, and a boiler that burns fuel to turn this generator.

[31] I will refer to this as western coal.

[32] This is a particular type of relationship specific investment, known as physical asset specificity.

[33] The cap was a multiple of the average use of fuel for the period 1985-1987. For these plants, the multiplier was set equal to 2.5 pounds of SO_2 per mmBTU.

[34] The multiplier for these plants was set equal to 1.2 pounds of SO_2 per mmBTU.

[35] Burning coal with a low sulfur content results in lower SO_2 emissions.

while others installed scrubbers.

Switching to an alternate coal was not easy. Being different chemically, simply burning Western coal in boilers not built for it would degrade the performance of the boiler[36]. Boilers built to burn Appalachian coal would have to be altered to accomodate western coal. What is remarkable is that such alteration was not thought possible, and the Clean Air Act Amendment forced a rethinking of this notion.

The specialization previously necessary to burn western coal now falls. The increased ability to switch coal implies a larger potential pool of suppliers. The propensity to engage in opportunistic behavior is thus attenuated, without requiring contractual provisions and the associated deficiencies with such provisions. This enables contracting parties to switch to fixed price contracts, as expected bargaining costs reduce.

Coal sourcing decisions by power plants, disaggregated by phase status, provides some evidence of whether a larger pool of suppliers was indeed employed . In figure 2 I use data from the EIA 786 form, and plot the percentage of contracts in every year from 1983 to 2000 that were recorded as burning both kinds of coal (Western and Appalachian).

We see that Phase I plants burn, increasingly, a greater proportion of both kinds of coal. Importantly, this occurs after 1990, the year the Amendment was announced. Phase II plants, by contrast, do not seem to change their mix of coal for much of the period. Towards the end, however, we can see a slight uptick for these plants. This fact will be important when considering the empirical specification.

Ellerman and Montero (1998) argue that only plants located in the midwest would be major switchers to low sulphur western coal. Plants on or near the

[36] For further details on the engineering aspect, see Bryers and Harding (1994).

east coast are too far away for the reduction in transportation cost to matter, and plants close to western coal mines would be sourcing from them anyway. In addition, Schmalensee et al (1998) note that some buyers underestimated the cheapness with which they could source low-sulfur coal, and so made investments in scrubbers, signing long term contracts with lower-sulfur coal suppliers in the process. In order to be consistent with Ellerman and Montero (1998), such buyers must be located on the east coast: they are both less likely to be aware of the cheapness of transport, and less likely to switch.

In Figure 3, we can see evidence in support of the argument above. In this, I plot the trend in the sulfur content of procured coal[37] by Phase status and location of the buyer. We see clearly that Phase I plants in the midwest reduce the sulfur content of their coal, and this reduction is a long term change, staying in place after the limits begin to bind. The sustained drop in sulfur content is what we would expect if the type of coal these plants burnt was being changed.

By contrast, Phase I plants on the east coast only record a temporary drop in their sulfur content - a result consistent with the argument that such plants installed scrubbers. We also see that Phase II plants in both locations do not show much change in their sulfur content, except for midwest plants, which towards the end show a small reduction. This reduction is what we would expect given the slight uptick over the same period shown by Phase II plants in Figure 2.

There are at least two other regulatory changes that may be important. First is the deregulation of the railroads, which got underway following the Staggers Act of 1980 . A majority of coal is transported using rail[38], and cheaper transportation

[37]I use information on the characteristics of delivered coal contained within the CTRDB to calculate this.

[38]For the sample derived post-cleaning from the Coal Transportation Rate Database, 70% of the observations record the transportation as taking place through rail for at least part of the way from the coal mine to the power plant.

(one effect of the deregulation) by rail may increase the ability to switch among suppliers.

The second major regulatory change that takes place here is the deregulation of the electricity market. I will attempt to account for both in the empirical analysis[39].

3 Specifying the Difference-in-Differences model

The main dataset I use is the Coal Transportation Rate Database (CTRDB)[40]. In addition to this, I take data from several other sources. Information on railroad statistics comes from the Federal Railroad Authority[41]. Information on electricity restructuring is taken from wesbites maintained by Energy Information Administration[42].

I use the Environment Protection Agency's website[43] to delineate power plants in the Coal Transportation Rate Database by phase status[44]. Table 2 lists descrip-

---

[39] Changes in the level of competition amongst mines may perhaps be an additional explanation. Undertaking relationship specific investment eliminates (in the extreme) the force of competition; still, it may be that changes in competition occur alongside the change in specificity of investment. Calculating the Herfindahl-Hirschliefer Index for coal mines over the period 1990 to 2000 results in a very stable score, at or below 0.01. Albeit crude, this result is suggestive of a high degree of competition throughout the period under study, that does not change over time.

[40] This data is available at http://www.eia.gov/cneaf/coal/ctrdb/database.html. FERC form 580, which surveys fuel and energy purchases by utilities, forms the basis for this dataset. The survey is held once every two years, and all investor-owned utilities that own at least one generating station of 50 MW or more are required to respond. These utilities sell power at wholesale rates to other utilities.

[41] I obtained this by running online queries at http://safetydata.fra.dot.gov/OfficeofSafety/Default.aspx.

[42] http://www.eia.gov/cneaf/electricity/page/restructuring/restructure_elect.html.

[43] I used the EPA's Air Markets Programs Data system, available at http://ampd.epa.gov/ampd to obtain the relevant information.

[44] Title IV of the Clean Air Act Amendment details the provisions for enactment of the SO_2 trading scheme. Under this Title, a total of 110 power plants are included as Phase 1 plants. Each power plant is assigned a unique identifying code. I use this code, called the plant code, to match the data in the Coal Transportation Rate Database with the information provided by the EPA's website. After matching, I obtain a total of 109 Phase

tive statistics and explanations for the variables I use.

I took a number of steps to ensure these data were accurate and reliable. The dataset includes a unique identifying code for each contract. This contract code, together with the plant code and year, identifies each observation in the data I eventually use for the analysis. In any given year, there were a number of duplicate observations, that is, in the same year two (or more) observations share the same entries; I exclude such duplicate copies. I dropped observations for which any or all of the following conditions held: the length of the contract was negative or greater than 100, the year signed or the year of expiry was equal to zero or the year of expiry was set before 1979, the year the dataset begins. After these, there 4,675 contract - plant observations, observed over a period of 20 years, with 14,777 total number of observations[45].

Dependent variables I use four definitions of the probability of choosing a fixed price contract, which are explained in Table 1[46]. These definitions are meant to capture increasing levels of variation in the type of contract, which also make up significant portions of the data[47]. The main dependent variable of interest is Z_2, because here we focus squarely on the tradeoff between contracts that contain provisions for renegotiation verus fixed price contracts. I also consider Z_3 and Z_4, the primary difference being the addition of other types of contracts which are relatively less easy to characterize. I choose to include such contracts as alternatives to fixed price contracts. Varying these definitions can be understood as a robustness check.

1 plants in the CTRDB.

[45] This is not equal to the product of the contract-plant by year as a change in pricing arrangement implies a change in contract code, and two years are omitted (see footnote 7).

[46] All definitions are made to enable estimation of a linear probability model. The reason for using such a model is described below.

[47] By "significant", I mean more than 1% of the total.

Main explanatory variables PHASE1 distinguishes between Phase I and Phase II plants. In the definition I use, I include power plants as Phase I plants, if any of their units were subject to reduction requirements under Phase I of the Clean Air Act Amendment. Time before and after treatment commences is captured by POST90, which takes on a value of 1 if the year is 1991 or later, and a value of zero otherwise. Finally, MIDWEST takes on a value of 1 if the plant is located in the midwest and 0 if it is not[48].

Additional variables To account for changes in transportation I use mainly two variables. MODES refers to the total number of different modes of transport used to ship coal. I expect that as alternate modes of transport increase, the propensity to sign fixed price contracts reduces as the uncertainty or complexity of the transaction rises. It may be also, however, that a greater number of modes of transportation imply more options to obtain coal, and so could raise the probability of a fixed price contract[49].

ACCIDENTS is a variable which attempts to capture directly the institutional changes the railroads went through[50]. If railroad performance improved, this should show up in a reduced number of accidents. I scale the total number of accidents by the total miles of track within any state to account for variation in

[48]MIDWEST plants include plants located in Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Oklahoma, Texas, and Wisconsin.

[49]Joskow (1987) reasons that more transportation options imply reduced scope for opportunism, as one can switch between suppliers more easily. Kozhevnikova and Lange (2009) define a dummy variable that equals one if a mode of transportation other than rail is used. I have considered such a variable, but find results do not change. These results are available on request.

[50]Although the Staggers Act was the main regulatory change, other regulatory changes also took place, notably the accounting procedure for depreciation that railroad companies could follow. See Saunders (2003). I try to account for these changes, by collapsing railroad performance into one variable. I use accidents because they serve best as a proxy for ex-post adaptation arising through the complexity of a transaction (Bajari and Tadelis 2001, Forbes and Lederman 2009), which may be affected by increased switching to rail.

state size and railroad networks, for the state where the mine is located[51].

I include dummy variables to account for the region where the coal is coming from: WEST for western coal, INTERIOR for interior coal and EAST for Appalachian coal[52]. These variables are meant to account for regional variation in the nature of coal, separate from asset-specificity considerations. Such variation implies a negative sign for WEST and INTERIOR (taking EAST as the base category). On the other hand, railroad deregulation made transportation cheaper, which implies a positive sign for the same variables. Finally, the increased ability to switch may reduce the importance of regional variation, implying weak effects.

I include a indicator variable (MINE-MOUTH) to account for mine-mouth plants. Being an extreme form of relationship specific investment, I expect MINE-MOUTH to be negatively correlated with the use of fixed price contracts.

I also include information on the delivery of the coal relative to ex-ante specification[53]. I take the logarithm of the absolute difference between the ex-ante specified and the delivered amount[54]. I consider three characteristics I deem to be relevant: the BTU, Ash and Sulfur content of the coal[55].

I interpret these variables[56] as reflecting the difficulty of specifying product

[51]If improvements in rail lead utilities to systematically choose suppliers, this variable may be endogenous. I explore an alternate definition of this variable, in terms of the state where the plant is located, and find a slight increase in the effect of relationship specific investment. This result is available on request.

[52]In the definition of these variables, I follow Joskow (1987). I use the term INTERIOR while Joskow uses the term MIDWEST. In all specifications, EAST is the base case.

[53]Ex-ante specifications are usually specified in terms of a lower limit on BTUs, and an upper limit on Ash and Sulfur content.

[54]In some cases, contract level characteristics were not available, so I substitute for them using similarly defined variables at the coal county level.

[55]Additional characteristics are Tons and Moisture content. BTU and Tons are likely to be reflections of the same concern since these represent energy obtained from the coal. Moisture is unlikely to be as much of a concern to boiler performance as Ash or to emission requirements as Sulfur so I do not consider it. Including moisture does not substantially alter the conclusions, these results are available on request.

[56]I refer to them as “delivery variables” from now on.

characteristics that are nonetheless important. The larger the difference the more it may be difficult to fully anticipate all relevant characteristics of the transaction, implying a negative correlation with fixed price contracts.

Phase II plants may also engage in fuel switching investment. To rule this out, for a majority of the specifications, I only include data until 1995[57]. Also, 1995 was the year limits were set to bind on Phase I plants, and most (if not all) fuel switching investment would have been carried out by this year, otherwise these plants would run the risk of not being compliant with the Amendment's requirement. Contract changes toward fixed price contracts should have been initiated by this year, if they are to be explained by the reduction in specialization of investment. There is a risk, however, that the effect of declining specialization may be under-estimated. We shall see, in Section 4.1, that the magnitude of such under-estimation does not appear to be large.

The US market for electricity underwent deregulation in the late 1990s[58]. Since I do not include data after 1995, I cannot account directly for the influence of deregulation. However, a major motivation for restructuring electricity generation was the high prices faced by consumers (Borenstein 2002). To account for any state-wise variation in electricity market performance which could have led to deregulation efforts and be a factor that confounds the estimated model , I define RESTRUCTURE as equal to 1 for those states that did eventually enact legislation to deregulate their markets, but only after 1990[59].

I employ a linear probability specification, for two reasons. One, the interpretation of the interactions in non-linear models has been subject to some controversy

[57] I examine the robustness of this cut-off in Section 4.1.

[58] The earliest state to begin restructuring efforts is Texas, which started in 1995 by the enactment of Senate Bill 373.

[59] For all other states RESTRUCTURE equals zero, irresepective of time period. For those states that did restructure, RESTRUCTURE equals zero for the period before 1990.

(Ai and Norton 2003, Puhani 2012). Using a linear model avoids these complications. Two, a linear probability model allows for multiple dimensions of fixed effects. Given the panel nature of the data, it is necessary to include both plant and year fixed effects[60]. Linear probability models, however, are defined such that the error term is heteroskedastic. To control for this, across all specifications, I cluster standard erros by plant[61].

Formally, I estimate[62]:

$$Z_{cpy} = \alpha_1 * PHASE1_p * POST90_y + \alpha_2 * PHASE1_p * POST90_y * MIDWEST_p \\ + \alpha_3 * MIDWEST_p * POST90_y + \beta * \mathbf{X_{cpy}} + \gamma_p + \delta_y + \epsilon_{cpy} \quad (1)$$

As explained above, Phase I plants may respond differently to the Amendment in their emission reduction strategies, due to their location (Ellerman and Montero 1998). Much of the take-up of western coal, and the investments toward switching, would be concentrated, therefore, for plants located in the midwest. For this reason, I expect α_2 and α_3 to be positive. If east coast plants installed scrubbers and signed long term contracts as a result (Schmalensee et al 1998), then given the inverse relationship between fixed price contracts and contract length, α_1 should be negative.

The vector X includes all the control variables discussed above. I also include plant and year fixed effects, γ_p and δ_y, respectively[63].

[60] A two way fixed effect model will account for unobserved heterogeneity over time and across plants. Such heterogeneity is likely to be important in the current setting, as Phase I plants were older and larger than Phase II. Plant size is unlikely to change over time, and will be differenced out as a consequence of the specification. A non-linear model, as far as I am aware, cannot be estimated with more than one dimension of fixed effect.

[61] Specifying panel robust standard errors in this manner controls for heteroskedasticity as well as serial correlation within clusters (Cameron and Trivedi 2005: pp 707-711).

[62] c indexes contract, p plant and y year.

[63] These fixed effects absorb PHASE1, POST90, MIDWEST and the interaction of PHASE1 with MIDWEST.

3.1 Pre-trend tests

Do Phase I and Phase II plants show similar trends before the announcement of the Amendment? Graphically, I show this in figure 4. This figure plots, for each year, the percentage of total existing contracts recorded as being fixed price contracts. We can see that Phase I plants use more fixed price contracts than Phase II. Importantly, the difference starts at the year 1990, which is exactly what one would expect if the hypothesis of fuel switching following the Clean Air Act Amendment is correct. I perform three formal tests to assess whether Phase I and Phase II plants shared similar trends before the announcement of the Amendment.

For the first, I only include data upto the commencement of treatment, drop the first two terms on equation 1 and include separate year dummy variables for Phase I and Phase II plants. The equation I estimate is[64]:

$$Z_{cpy} = \sum_{1979}^{1990} \beta_{1y} * PHASE1_{py} + \sum_{1979}^{1990} \beta_{2y} * (1 - PHASE1_{py}) + \Delta * X_{cpy} + \epsilon_{cpy} \quad (2)$$

I then jointly test whether the coefficients for the control and treatment year dummies are significantly different from each other:

$$H_0 : \beta_{1y} - \beta_{2y} = 0 \forall y = 1979...1990, y \neq 1988, 1989 \quad (3)$$

Panel A of Table 3 reports the results of this test. All standard errors employed for estimating equation 2 were clustered at the plant level. We observe that for all definitions, the null hypothesis of equal effect cannot be rejected at conventional

[64] Z_1, Z_2, Z_3 and Z_4 are the outcome variables I employ. The explanatory variables I use are MINE-MOUTH, WEST, INTERIOR, MODES, ACCIDENTS, BTU, SULF and ASH along with the year dummies for treatment and control groups.

levels of significance.

Panel B reports the result of a similar test, only this time I compare Phase 1 plants by location. That is, I compare Phase 1 plants located in the midwest to Phase 1 plants located on the east coast, and carry out the exact same test as above. We can see that once again, the null hypothesis of equal effect across these two groups cannot be rejected.

In the third test, I again only include data upto 1990, drop the first two terms from equation 2 but this time include a time trend interacted with PHASE1 and MIDWEST. If the coefficient on the interactions of the time trend, PHASE1 and MIDWEST is statistically insignificant, then we may conclude that there is little difference between Phase I and Phase II plants before the Amendment was announced. The equation I estimate is[65]:

$$\begin{aligned} Z_{cpy} = \gamma_1 * TREND_y + \gamma_2 * PHASE1_p * TREND_y \\ + \gamma_3 * PHASE1_p * MIDWEST_p * TREND_y + \gamma_4 * MIDWEST_p * TREND_y \\ + \Delta * X_{cpy} + \lambda_p + \epsilon_{cpy} \end{aligned} \quad (4)$$

where TREND equals 1978 subtracted from the year the contract is observed in, and the test being

$$H_0 : \gamma_2 = 0 \quad (5)$$

Panel C of Table 3 reports the results of this test. Once again, all standard errors used to estimate equation 4 are clustered by plant. For all definitions, the null hypothesis cannot be rejected. On the basis of these two tests, we may

[65] As before, Z_1, Z_2, Z_3 and Z_4 are the outcome variables I employ; the other explanatory variables I use are MINE-MOUTH, WEST, INTERIOR, MODES, ACCIDENTS, BTU, SULF and ASH. For this test, I also include plant fixed effects.

conclude that Phase I and Phase II plants share similar trends in using fixed price contracts before the commencement of treatment.

4 Estimates of the specified model

Table 4 presents estimates of the base specification. PHASE1*POST90 is statistically insignificant, although of the expected sign. The main interaction term of interest - PHASE1*POST90*MIDWEST - has the expected sign and it is statistically significant, indicating that both railroad deregulation and the Amendment act together in causing the specificity of investment to reduce. POST90*MIDWEST has the expected sign but is statisticially insignificant. The pattern of these results is invariant to changes in the definition of the pricing outcome variable. In addition, the point estimates are all relatively similar across the definitions, lending further strength to the results.

Electricity restructuring appears to have a negative influence on the propensity to write fixed price contracts, although it must be kept in mind that by 1995 only Texas had announced plans for deregulation. Out of the railroad deregulation variables, ACCIDENTS has the expected sign, is statistically significant and the point estimates appear quite large.

Mine mouth plants are negatively correlated with the probability of choosing a fixed price contract, a result that is as per expectation but is statistically insignificant. Western coal does not show a statistically significant effect, nor does interior coal, suggesting that the importance of inter-regional variation in coal uniformity has indeed fallen.

A previous round of interaction between the supplier and buyer appears strongly negatively correlated with using fixed price contracts. This suggests that rather than eliminating the fear of opportunism, having a previous relationship plays a role in sharing information regarding likely hold-ups during contract execution. Dedicated assets are strongly negatively correlated with using fixed price contracts, a result predicted by theory, although there is no evidence that a quadratic relationship is justified. Although statistically highly significant, the point estimates for both repeated interaction and dedicated assets are smaller than those for specialized investment and for railroad deregulation, with the magnitude being roughly halved.

Finally, out of the delivery variables, only suflur shows a statistically significant effect, although of relatively small magnitude.

Economically speaking, are the results meaningful? Comparing across the indicator variables, the triple interaction term certainly does seem to have a large effect, approximately raising the probability of choosing a fixed price contract by 0.17 to 0.18 probability units, equivalent to between 0.61 to 0.64 standard deviations[66].

4.1 Equation and Sample specification

I conduct various specification checks in Table 5[67]. In column (1), I report the results that obtain when the cut-off year is raised by one, that is, data up to and including the year 1996 is included. Given the discussion in Section 3, the more

[66]It may be the case, however, that while the total number of contracts is affected dispropotionately, the energy delivered through these contracts is not. I therefore use the information in the CTRDB on the BTU content of coal shipped to calculate a similar figure in terms of the percentage of total BTUs arriving through fixed price contracts. I find similar results, that is, Phase I plants in the midwest are postively correlated with energy sourced by fixed price contracts. This correlation is highly significant. Details are available on request.

[67]I do not report all the coefficients. Also, all the results are reported with Z_2 as the dependent variable. Very similar results obtain when Z_2, Z_3, Z_4 are the dependent variables. Results with these variables, as well as the coefficients, are not reported, but are available on request.

years are included, the greater should be the estimate on the triple interaction term.

We see that this is indeed the case, the point estimate on PHASE1*POST90*MIDWEST increases from 0.175 to 0.214. We also observe that the error for the latter estimate remains the same as for the former. In Column (2), I do not exclude any years - we see that the estimate rises, this time to 0.255. However, as mentioned above, the problem with including years close to, and including, 2000 is that Phase II plants appear to also respond which risks the empirical design, despite the stronger estimate. Importantly, although the estimate rises, the rise is still within the same order of magnitude. Therefore, while the main estimates underidentify the effect of declining specificity, it would appear to be a reasonable trade-off for a safer design.

Another interesting result that occurs when we include all years is with respect to the PHASE1*POST90 coefficient. This variable is expected to be negatively correlated with fixed price contract use, as it captures the choice of east coast plants to invest in scrubbers and, as per Schmalensee et al (1998), sign long term contracts as a result. Although the sign is observed negative in the main specification, it is only when we include all years is this correlation statistically significant. The point estimate for this interaction is however far smaller than for the triple interaction term, indicating that the strength of this response is quite weak, which is perhaps why the coefficient is insignificant when some years are excluded.

Kozhevnikova and Lange (2009) exclude spot contracts and in column (3) I do the same. Keeping in mind my earlier argument that spot contracts are simply viewed analogous to fixed price contracts, that is, contract structures that inherently do not provide support for ex-post opportunism and are one extreme on the contract length dimension, it is argubaly not appropriate to exclude such contracts, as their use is predicted when the extent of specialization reduces. I expect, therefore, when removing these contracts, the predicted effect should fall, as an important margin of reponse by the buyer is eliminated. Indeed, we can see that this does happen, with the fall being large enough to render the point estimate statistically insignificant. Excluding spot contracts does not, therefore, appear to be appropriate.

In column (4), I examine the possible influence of coal protection programs that some states enacted in the wake of the Amendment. To protect local coal interests, five states - Illinois, Indiana, Ohio, Kentucky and Pennsylvania - enacted legislation incentivising the use of coal from their mines (Ellerman and Montero 1998). I interact POST90 with an indicator variable for these five states (PROTECT). As only Phase I plants are likely to be affected by such legislation, I define PROTECT as being 1 for Phase I plants in these five states and zero otherwise. We can see the estimates for the interaction variables are little altered, while the POST90*PROTECT is not statistically significant. Given that such legislation was only temporary, this result is not surprising.

Finally, we may be concerned that the owners of these plants - the utility companies - may differ amongst each other in ways that could bias the estimated results[68]. I attempt to control for such unobserved heterogeneity by including utility specific fixed effects in Column (5), under the assumption that such differences are time-invariant. We observe that the point estimate on the triple interaction term remains statistically significant, is of the expected sign and falls compared to the main specification, but the fall is relatively small (0.175 to 0.171).

[68]For instance, companies can have a different culture, or can differ in terms of their how they operate.

4.2 Incorporating Length

So far length has not been discussed. All three previous studies I have quoted that study this particular set of transactions, whether over a cross-section or a panel, look at contractual length. Incorporating length into the discussion is clearly required. The question is how.

The problem with trying to include length is that not only is it endogenous to the choice of pricing structure, but it is not a causal factor in determining pricing rules. Rather, both pricing and length are outcomes of the underlying transaction characteristics. I therefore estimate these two variables using a seemingly unrelated regression (SUR) specification. Table 6 reports the results[69].

Columns (1) and (2) show the results that obtain considering Z_2 and length together, with the sample and variables the same as those reported in Table 4[70]. In addition to the variables in the main specification, I include, for the Z_2 equation, Z-scores for the different coal characteristics. These z-scores were used by Kozhevnikova and Lange (2009) to instrument for pricing structure[71]. Such z-scores capture the freedom of the supplier to choose coal specifications and thus the amount of rent the supplier can potentially stand to gain. Writing fixed price contracts can be thought of a way to counter such rent-seeking activity.

The expected direction in which the interaction variables will affect length should be opposite to those predicted for the pricing structure equation. Given the discussion in Section 2, length and the use of fixed price contracts should be

[69] I only report results when considering Z_2 and length together. Results considering alternative definitions of pricing structure are very similar, and I do not report them to save on space. These results are available on request.

[70] I cannot include fixed effects, so I include indicator variables for plant and year.

[71] Such a specification is counter to the argument here, because it assumes that pricing affects length, while I maintain that both are outcomes and it is therefore incorrect to account for the influence of one on the other. Doing so confuses, in my opinion, effect for cause.

negatively correlated; it is difficult to imagine a 20 year contract which attempts to fix prices in every year.

We can see that the results for pricing structure are quite similar to those estimated earlier. The point estimate is very close, lending further strength to the results estimated so far. Interestingly, in the case of length, all the interaction variables are statistically significant, with the expected signs. We can also see that the size of the coefficient follow expectations - if, as argued above, PHASE1*POST90 exerts a smaller influence that the triple interaction variable, we should expect the same when length is the outcome variable.

Although in the individual equations, some of the interaction variables are insignificant, when conducting joint tests, the null hypothesis of zero effect can be rejected for all three interaction terms. These results are given in Column (3), with the p-value given in parentheses underneath the chi-square value for the test. I also report, in Columns (4) and (5), the results that obtain when the logarithm of length is used. We can see that these results are very similar[72]. None of the z-score variables are, however, significant.

Finally, I also report the Breusch-Pagan test statistic. This statistic helps to ascertain whether or not the joint estimation structure is warranted, by testing whether the errors in the two equations are correlated. We can see that the errors are negatively correlated, and the value of the statistic in both cases shown is far above the critical value[73] required to reject the null hypothesis at the 1% level of significance. These results validate the use of the joint estimation technique. Other definitions of pricing structure also show similar results, and are avaiable on request.

[72] Results for joint tests are also similar to those shown in Column (3). Once again, these are not reported to save on space, but can be had from the author.

[73] The critical value for a chi-square test with two degrees of freedom is 9.21 at the 1% level of significance.

4.3 Comparing measures of relationship specific investment

Given the existence of previous work on the transactions studied in this paper, it is important to ask whether the estimates in this paper compare to those derived earlier. All previous studies of coal mine - power plant contracts in the US (Joskow 1987, Kerkvliet and Shogren 2001, Kozhevnikova and Lange 2009) use length as the dependent variable. In order to compare the present study to these, I also use length as the dependent variable, using estimates from the SUR model[74].

Such a comparison serves two purposes. First, we can see how the influence of a particular variable varies across studies. For instance, if the hypothesis of declining specificity is true, we should find that estimated coefficients for various measurements of relationship specific investments should be lower than Joskow (1987) or Kerkvliet and Shogren (2001), who analyzed cross sections of contracts in the early 1980s. Second, we can compare within the present study the estimated coefficients of various alternate measures of relationship specific investment. This will indicate the relative importance of using the triple difference specification.

In Table 7, I report the variables, definitions and coefficients estimated by the three papers cited above for all the variables that measure relationship specific investment. Below each variable name I include the expected sign. In Columns (1) and (2) I report the lowest and highest (in terms of magnitude) coefficients in the papers. Below these coefficients, in parentheses, I report the level of significance at which one can reject the null hypothesis that the estimated coefficient is equal to zero[75]. Reporting bounds on coefficients in this manner allows us to see how

[74] To be sure, only Joskow (1987) explicitly argued for the inclusion of variables that capture physical specialization, which is the central focus of this paper. Dedicated assets may however follow from physical specialization, and so I include measures of dedicated assets in what follows.

[75] I tried to only include coefficients which were significant at the 5% level of significance.

robust the estimated coefficient is, as a lower difference between the upper and lower estimates indicates a tightly estimated relationship, irrespective of sample selection or specification differences[76].

In Column (3) and (4), I report the results that obtain when I estimated the SUR specification. The coefficients on the *Quantity* variable in Joskow (1987)[77], and the *Plant Dedicated Assets* and *Mine Dedicated Assets* variables in Kozhevnikova and Lange (2009) are estimated from the SUR specification, with the DEDICATE variable being replaced by *Quantity* and then by *Plant Dedicated Assets* and *Mine Dedicated Assets* respectively[78]. If earlier papers reported estimates with the logarithm of length, then they are included as well. The coefficients on *WEST*, *MIDWEST* and the interaction variables are taken from the SUR specification[79].

Comparing across studies, we can see that indeed relationship specific investment declines. While Joskow estimates that cross-regional variation (captured by *WEST* and *MIDWEST*) increased contract length by between 5 to 6 years (for WEST) and 2.5 to 3.5 years (for *MIDWEST*), I find the same variables exert far smaller influence, with the fall in size being approximately 50%. In addition, the difference between *WEST* and *MIDWEST* also falls, which is expected if cross-regional variation becomes less important.

However, in some cases, coefficients were always insignificant in the specifications reported in the paper. For these, I include a pair of empty parentheses.

[76]The differences in coefficients from earlier studies come from the differences in specifications they report. For the present study, such variation comes from the variations in defining the pricing outcome variable.

[77]Note that his *WEST* and *MIDWEST* are exactly analogous to the WEST and INTERIOR indicator variables I use.

[78]*Quantity* in Joskow (1987) is defined as the product of the contracted BTU content with the contracted tonnage, and it is not clear whether Joskow considered upper or lower limits. *Minimum Quantity* in Kozhevnikova and Lange (2009) is defined as the lower limit of the contracted tonnage. I take as my definition of *Quantity* the product of the lower limit of the contracted BTU content with the lower limit of the contracted tonnage, and so for this reason do not include *Minimum Quantity*.

[79]I do not have the data required to estimate the two variables capturing relationship specific investment in Kerkvliet and Shogren (2001).

The marginal effect of *Quantity* (in Column (1)) was derived at the average level reported in Joskow (1987)[80], while the marginal effect shown in Columns 3 was calculated for the entire sample and then averaged[81]. We see, both in levels and logs, that the marginal effect for this variable is lower. The estimate in levels is not necessarily comparable, as I use billions of BTUs while Joskow uses trillions, but in logs, the estimate was derived using a log specification on quantity, thus making the estimate in Column (4) directly comparable to that in (2), as this is an elasticity and so free of units. We can see that here too the impact roughly halves.

Comparing to the Kozhevnikova and Lange (2009) study, we can see that the estimates in the current study are as expected by theory, a result in contrast to the original paper. *Plant Dedicated Assets* has a positive effect on length, and in magnitude terms is similar to what Kozhenvikova and Lange (2009) find, albeit slighlty lower. *Mine Dedicated Assets* has the expected sign, but is not robust across specifications, becoming insignificant once we use the log of length.

Comparing within the present study, we see that although dedicated assets correlate strongly with increased contract length, this correlation is typically lower in terms of magnitude than specialized investment[82]. Importantly, we can see that the interaction variables are approximately as large as *MIDWEST*, and slightly lower than *WEST*. The triple interaction variable, in particular, has at its largest an effect almost as large as *WEST*. The effect I have tried to capture through the triple interaction variables is, in this sense, meaningful to those suggested by the Joskow study[83].

[80]Not having access to the data that Joskow (1987) uses, I cannot calculate standard errors of the marginal effect. For the log specification, only the log of quantity was entered, so I can use the standard errors Joskow reports.

[81]This estimate is very close to the marginal effect at the average level.

[82]Kervliet and Shogren 2001 find a similar result.

[83]Once again, the comparison to Joskow is made because this is the only other paper

Finally, we may turn our attention to the direction and variation of the coefficients themselves. The sign on all the coefficients are as per theoretical prediction[84]. The variation of the coefficients estimated in the present study is also small, implying that the results obtained are robust. The conclusion one may cautiously take from this is that, even with a research design that is less susceptible to the problems of measuring the influence of relationship specific investment, we can reject the hypothesis that relationship specific investments do not matter.

5 Concluding remarks

This paper attempts to make is to overcome a basic source of possible bias in empirical tests of transaction cost theory. The results show comprehensively that as investment becomes less specialized, contracting parties prefer to write shorter term, fixed price contracts.

There are however a few limitations to the present study. For one, there is no one satisfactory econometric model that allows for the estimation of a difference-in-difference model for categorical models, if we wish to consider more than one level at which unobserved heterogeniety may exist. Given that most study of organizations is likely to focus on a only a few comparable alternatives, the development of such a model is highly needed. I have used information at the plant level. Unit level information may help in providing additional evidence to the plausibility of the findings here.

Highly relevant is the lack of any definition of specific assets, complexity or

---

that attempts to capture the influence of physical specialization.

[84]Note that for Joskow's *Quantity*, the suggested relationship is quadratic and inverse-U shaped, which makes the sign of the marginal effect depend on the size of the individual coefficients. The sign may be negative if the coefficient on the square of *Quantity* is large enough. We see that in the present case this is not true.

uncertainty that can be transparently applied to data. Put another way, the empirical measurement of transaction characteristics lags behind the theoretical work. Therefore, it is difficult to rule out measurement error or omitted variable bias entirely. There may also be other ways to solve the problem of simultaneous choice of transaction and contract type. For instance, careful consideration of why the parties decide to engage in the transaction could lead to gathering additional kinds of data, and the problem could be overcome. The data requirement for a study of this kind may however be fairly daunting. For instance, in the present case, we would need to know why plants chose to locate where they did, their engineering technology, the state of the transmission network and the nature of the market they were selling power to.

Finally, it is important to realize that the reduction takes place as a result of a deliberate alteration of the regulatory regime. It is relevant, therefore, to realize that this theory is well suited to understand complex transactions that take place in the face of great uncertainty. In turn, most policy decisions revolve around the appropriate organization of markets where such problems are often encountered - for example, deregulation of electricity generation and distribution. There is clearly a need to explore further the interaction between the policies made at a macro level and contracting behavior at the more micro level. Such study may deliver two benefits: it may make for more sensible policy making, and it perhaps permits better tests of transaction cost theory, and of contract theories more generally.

References

1. Alchian, Armen A. and H. Demsetz. 1972. "Production, Information Costs and Economic Organization", *The American Economic Review*, Vol. 62, No. 5: 777-795

2. Ai, Chunron and E. C. Norton. 2003. "Interaction terms in probit and logit models", *Economics Letters*, Vol. 80, Issue 1: 123-129

3. Arrow, Kenneth. 1969. "The organization of economic activity: Issues pertinent to the choice of market versus non-market allocation" in *The Analysis and Evaluation of Public Expenditures: the PBB system*, Joint Economic Committee Compendium, 91st Congress, 1st Section, Vol. 1, Government Printing Office: Washington D.C

4. Bajari, Patrick and S. Tadelis. 2001. "Incentives versus Transaction Costs: A Theory of Procurement Contracts" *The RAND Journal of Economics* Vol. 32, No. 3: 387-407

5. Borenstein, Severin. 2002. "The trouble with electricity markets: understanding California's restructuring disaster", *The Journal of Economic Perspectives* Vol. 16, No. 1: 191-211.

6. Bryers, Richard W. and N.S. Harding. 1994. *Coal blending and switching of low-sulfur western coals*, American Society of Mechanical Engineers

7. Cameron, Colin and P. K Trivedi, *Microeconometrics*, 2005

8. Carpenter, A.M. and N.M. Skorupska. 1993. *Coal combustion analysis and testing*, IEACR/64, London: IEA Coal Research

9. Coase, Ronald H. 1937. "The Nature of the Firm" *Economica*, Vol. 4: 386 405

10. — 1960. "The Problem of Social Cost" *Journal of Law and Economics*, Vol. 3: 1 44

11. Corts, Kenneth and J. Singh. 2004 "The effect of repeated interaction on Contract Choice: evidence from offshore drilling", *Journal of Law, Economics and Organization*, Vol. 20, No.1: 230 - 260

12. Crocker, Keith J. and S.E. Masten. 1991. "Pretia ex Machina? Prices and Process in Long-Term Contracts", *Journal of Law and Economics*, Vol. 34, No. 1: 69 - 99

13. Forbes, Silke J. and M. Lederman. 2009. "Adaptation and Vertical Integration in the Airline Industry", *The American Economic Review*, Volume 99, No. 5: 1831-1849

14. Frost, David C., B. Wallbank and W.R. Leeder. 1978. *Analytical Methods for Coal and Coal Products*, New York: Academic Press

15. Gibbons, Robert. 2005. "Four formal(izable) theories of the firm?", *Journal of Economic Behavior and Organization*, Vol. 58, Issue 2: 200 - 245

16. Grossman, Sanford, and O. Hart. 1986. "The costs and benefits of ownership: A theory of vertical and lateral integration", *Journal of Political Economy*, Vol. 94: 691 719

17. Goldberg, Victor and J. Erickson. 1987. "Quantity and Price Adjustment in Long-Term contracts: A case study of petroleum coke", *Journal of Law and Economics*, Vol. 30, No. 2: pp. 369 - 398

18. Hart, Oliver and J. Moore. 1990. "Property rights and the nature of the firm", *Journal of Political Economy*, Vol. 98, No. 6: 1119 - 1158

19. Joskow, Paul L. 1985. "Vertical Integration and Long-term Contracts: The Case of Coal-burning Electric Generating Plants", *Journal of Law Economics and Organization*, Vol. 1, No. 1: 33-80

20. — 1987. “Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets”, *The American Economic Review*, Vol. 77, No. 1: 168-185

21. Klein Benjamin, R.G Crawford, and A. A. Alchian. 1978. “Vertical Integration, Appropriable Rents and the Competitive Contracting Process”, *Journal of Law and Economics*, Vol. 21, No. 2: 297-326

22. Kozhevnikova, Maria and I. Lange. 2009. “Determinants of Contract Duration: Further evidence from Coal-Fired Power Plants”, *Review of Industrial Organization*, Volume 34, No. 3: 217-229

23. Lafontaine, Francine and M. Slade. 2007. “Vertical Integration and Firm Boundaries: The Evidence.”, *Journal of Economic Literature*, Volume 45, No. 3: 629-685.

24. Macher, J. T, and B. D. Richman. 2008. “Transaction Cost Economics: An Assessment of Empirical Research in the Social Sciences”, *Business and Politics*, Volume 10, Issue 1

25. Nunn, Nathan. 2007. “Relationship-specificity, Incomplete contracts and the Pattern of Trade”, *Quarterly Journal of Economics*, Vol. 122, No. 2: 569 - 600

26. Puhani, Patrick A. 2012. “The Treatment Effect, the Cross Difference, and the Interaction Term in Nonlinear Difference-in-Differences Models”, *Economics Letters*, Vol. 115, Issue 1: 85 -87

27. Saunders, Richard. 2003. *Main Lines: Rebirth of the North American Railroads 1970 - 2002*, Illinois: Northern Illinois University Press

28. Shelanski, H. A and P. G. Klein. 1995. "Empirical Research in Transaction Cost Economics: A Review and Assessment", *Journal of Law, Economics and Organization*, Vol. 11, No. 2: 335 - 361

29. Tadelis, Steven. 2002. "Complexity, Flexibility and the Make or Buy decision", *American Economic Review: American Economic Association Papers and Proceedings* Vol. 92, No. 2: 433 437

30. Van Krevelen, D.W., 1993, *Coal*, 3rd Edition. Amsterdam: Elsevier.

31. Williams, A., M. Porkashanian, M., J. M. Jones, and Skorupska. 2000. *Combustion and Gasification of Coal*, New York: Taylor and Francis, New York.

32. Williamson, O. E., 1975, *Markets and Hierarchies: Analysis and Antitrust implications*, New York: Free Press.

33. — 1979, "Transaction-Cost Economics: The Governance of Contractual Relations", *Journal of Law and Economics*, Vol. 22: 233 262

34. — 1985, *The Economic Institutions of Capitalism: Firms, Markets and Relational Contracting*, New York: Free Press

35. — 1996, *The Mechanisms of Governance*, New York: Oxford University Press

Figures

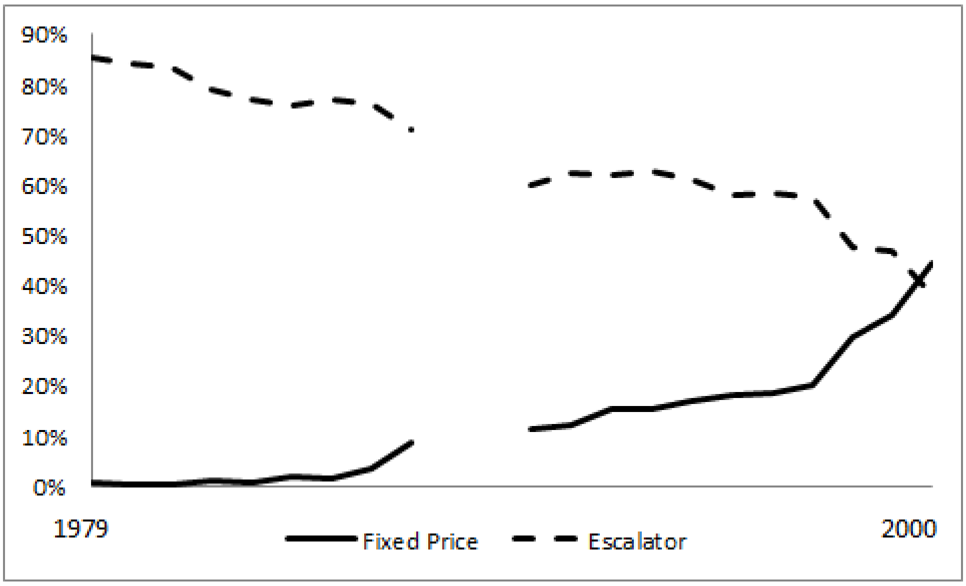

Figure 1: The rise of Fixed Price contracts: Fixed Price and Escalator contracts as a percentage of Total Contracts in existence in every year between 1979 and 2000 (Source: Coal Transportation Rate Database, Author's Calculation)

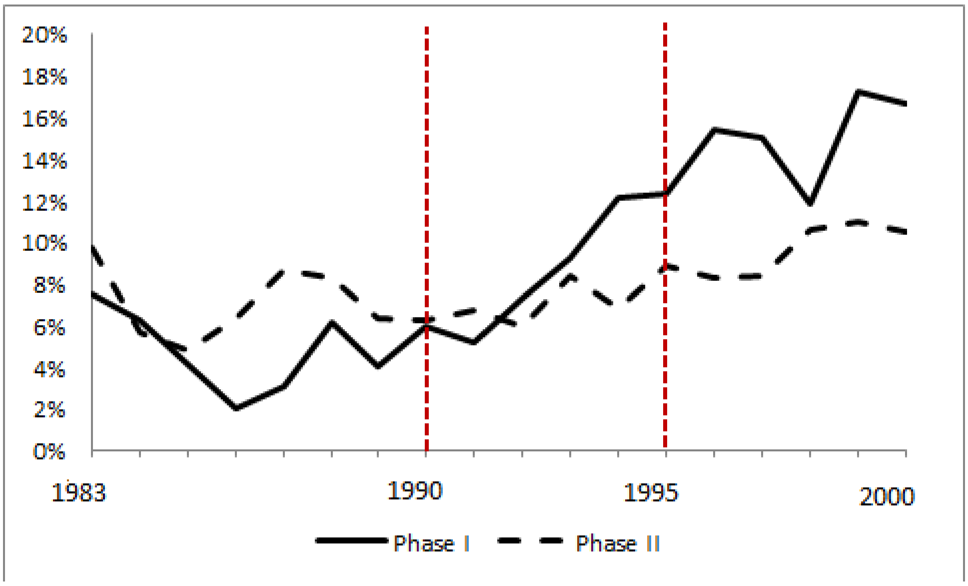

Figure 2: Suggestive evidence of Mixing: Phase I plants increasingly mix their coal (Source: EIA 786, Author's Calculation)

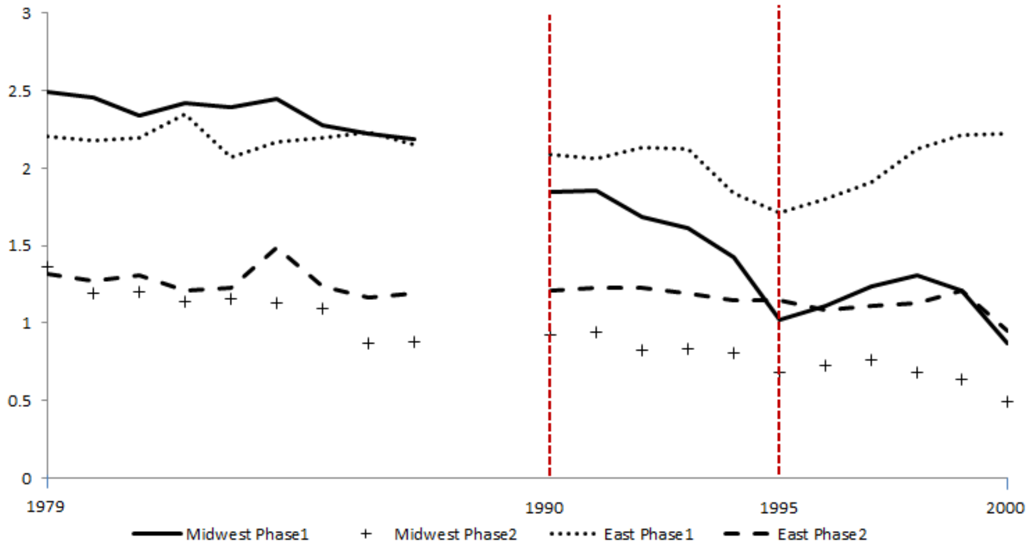

Figure 3: Changes in Supplier Profile by Phase Status and Location (Source: Coal Transportation Rate Database, Author's Calculation)

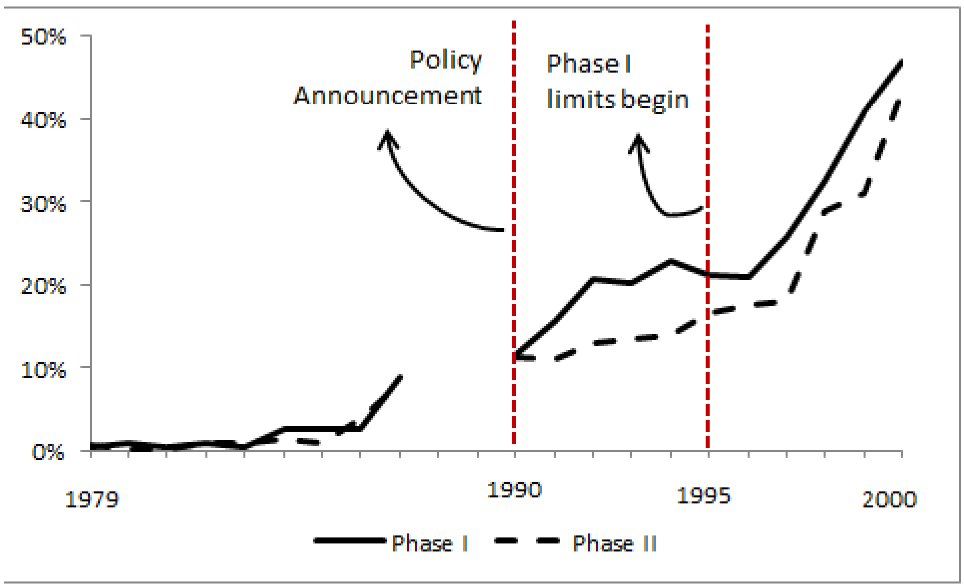

Figure 4: Motivation for the Difference-in-Difference Strategy: Phase I plants more likely to use Fixed Price contracts (Source: Coal Transportation Rate Database, Author's Calculation)

Table 1: Definitions of Dependent Variable

Dependent Variable	Contract type included	Values	Percentage
Z_1	Fixed price contracts	1	
[0.096]	Escalator clause contracts	0	
(0.295)			
Z_2	Fixed price contracts	1	
[0.084]	Escalator clause contracts	0	
(0.278)	Cost plus contracts	0	
	Price renegotiation	0	
Z_3	Fixed price contracts	1	
[0.083]	Price tied to market	0	
(0.276)	Escalator clause contracts	0	
	Price renegotiation	0	
	Cost plus contracts	0	
Z_4	Fixed price contracts	1	12.00%
[0.079]	Price tied to market	0	1.38%
(0.270)	Escalator + Price tied to market	0	2.82%
	Escalator clause contracts	0	66.80%
	Escalator + price renegotiation	0	1.29%
	Price renegotiation	0	6.83%
	Cost plus contracts	0	3.51%

Source: Coal Transportation Rate Database, Author's Calculation. Contracts that had a share lower than 1% in the data obtained post cleaning, or recorded as "Other" are not included. For each variable, below its name, the mean is given in square brackets and the standard deviation in parentheses.

Table 2: A Brief Summary of the Data

Name	Observations	Mean	Standard Deviation	Min	Max	Source	Description
PHASE1	15191	0.294	0.455	0	1	EPA	Indicator variable that equals 1 if contract is with a plant targeted under Phase I of Title IV of the Clean Air Act Amendment of 1990
MODES	14777	1.387	0.657	0	4	CTRDB	The total number of unique modes of transportation used to ship coal
ACCIDENTS	14240	0.007	0.030	9.34e-07	0.3808	FRA	Total accidents divided by total track miles for the state where the mine is located
MINE-MOUTH	14777	0.015	0.121	0	1	CTRDB	Indicator variable for whether plant is located at the mouth of a mine
LENGTH	14777	5.953	6.513	0	48	CTRDB	Length of the contract, calculated by subtracting year of signing from the year of expiry
WEST	14777	0.203	0.402	0	1	CTRDB	Indicator variable for whether coal supplier is located in the Western region
INTERIOR	14777	0.125	0.331	0	1	CTRDB	Indicator variable for whether coal supplier is located in the Interior region
EAST	14777	0.664	0.472	0	1	CTRDB	Indicator variable for whether coal supplier is located in the Appalachian region
MIDWEST	14777	0.420	0.493	0	1	CTRDB	Indicator variable for whether plant is located in the midwest

REPEAT	15375	0.817	0.386	0	1	CTRDB	Indicator variable for whether the plant and the supplier contracted with each other in the past
DEDICATE	13490	0.646	0.537	1.50e-05	42.083	CTRDB	Ratio of quantity within the specific plant-supplier contract to quantity for all contracts the supplier holds
BTU	14611	5.2856	1.4339	0	11.3679	CTRDB	The logarithm of the difference between the ex-ante specified BTU limit and the delivered amount
SULF	14324	-1.0702	1.1640	-17.3286	4.3087	CTRDB	The logarithm of the difference between the ex-ante specified sulfur limit and the delivered amount
ASH	14363	0.7801	1.1010	-6.1455	4.2427	CTRDB	The logarithm of the difference between the ex-ante specified ash limit and the delivered amount
QUANTITY	13489	10.1189	10.2601	2.55e-05	708.2199	CTRDB	Total quantity, in billion BTUs (derived by multiplying contracted for total tons by contracted for BTU content
YEAR	14777	1989	6.4680	1979	2000	CTRDB	The difference between the current year and the year the contract is set to expire
TOTALDISTANCE	14777	425.4985	541.8192	0	12040	CTRDB	The total distance the coal is shipped over, in miles

Note: CTRDB refers to the Coal Transportation Rate Database, EPA refers to EPA's website which provides information on phase status of plants and FRA refers to the Office of Safety Analysis, Federal Railroad Authority which provides information on accidents and track miles per employee

Table 3: Pre-Trend tests

	Z_1	Z_2	Z_3	Z_4
Panel A: Test #1				
F-Statistic	0.26	0.49	0.49	0.35
p-value	0.98	0.88	0.87	0.95
Panel B: Test #2				
F-Statistic	1.48	1.49	1.47	1.79
p-value	0.15	0.15	0.15	0.07
Observations	4930	5654	5764	5965
Number of Plants	295	302	305	305
Plant FE	Y	Y	Y	Y
Panel C: Test #3				
TREND	0.0209***	0.0174***	0.0167***	0.0158***
	(0.0057)	(0.0048)	(0.0047)	(0.0045)
PHASE1*TREND	-0.0020	-0.0027	-0.0021	-0.0035
	(0.0086)	(0.0067)	(0.0066)	(0.0057)
PHASE1*MIDWEST* TREND	0.0026	0.0033	0.0027	0.0038
	(0.0099)	(0.008)	(0.008)	(0.0073)
MIDWEST*TREND	-0.0135**	-0.0105	-0.0098	-0.0085
	(0.0063)	(0.0054)	(0.0053)	(0.0051)
R-Squared	0.076	0.060	0.058	0.055
Observations	4846	5568	5678	5879
Number of Plants	282	288	291	291
Plant FE	Y	Y	Y	Y

In all the regressions, standard errors are clustered by plant. For Panel C, standard errors for the estimated coefficients are in parentheses below the estimated coefficients. *** p< 0.01, ** p<0.05.

Table 4: Adoption of Fixed Price Contracts: Linear Probability Models

	Z_1	Z_2	Z_3	Z_4
PHASE1*POST90	-0.0500	-0.0423	-0.0390	-0.0365
	(0.0494)	(0.0417)	(0.0411)	(0.0347)
PHASE1*POST90*MIDWEST	0.164**	0.175**	0.173**	0.167**
	(0.0811)	(0.0736)	(0.0732)	(0.0682)
POST90*MIDWEST	0.0119	0.0144	0.0162	0.0281
	(0.0454)	(0.0375)	(0.0368)	(0.0336)
RESTRUCTURE	-0.306**	-0.289**	-0.288**	-0.286**
	(0.121)	(0.117)	(0.118)	(0.117)
MODES	-0.00299	-0.00858	-0.00746	-0.00789
	(0.0110)	(0.0106)	(0.0104)	(0.0101)
ACCIDENTS	-0.409***	-0.409***	-0.406***	-0.416***
	(0.134)	(0.122)	(0.122)	(0.109)
MINE-MOUTH	-0.0259	-0.0397	-0.0401	-0.0623
	(0.0428)	(0.0366)	(0.0367)	(0.0469)
WEST	0.0171	0.0310	0.0305	0.0281
	(0.0440)	(0.0413)	(0.0413)	(0.0405)
INTERIOR	-0.0607	-0.0691	-0.069	-0.0655
	(0.0417)	(0.0352)	(0.0352)	(0.0345)
REPEAT	-0.0825***	-0.0774***	-0.0757***	-0.0789***
	(0.0133)	(0.0126)	(0.0123)	(0.0124)
DEDICATE	-0.0746**	-0.0755**	-0.0731**	-0.0882***
	(0.0346)	(0.0328)	(0.0321)	(0.0334)
DEDICATE_SQUARED	0.0211	0.0234	0.0218	0.0282
	(0.0227)	(0.0203)	(0.0198)	(0.0205)

Table 4 Continued

	Z_1	Z_2	Z_3	Z_4
BTU	0.00340	0.000525	0.000713	-0.000154
	(0.00391)	(0.00347)	(0.00342)	(0.00319)
SULF	-0.0119***	-0.00990**	-0.00996**	-0.0104**
	(0.00448)	(0.00428)	(0.00424)	(0.00418)
ASH	-0.00221	-0.00114	-0.00115	-0.000427
	(0.00323)	(0.00286)	(0.00276)	(0.00265)
Constant	0.257***	0.252***	0.243***	0.227***
	(0.0380)	(0.0361)	(0.0350)	(0.0352)
Plant Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Observations	7,660	8,709	8,864	9,303
R-squared	0.126	0.109	0.108	0.103
Number of plantcode	292	296	299	299

All standard errors are clustered by plant. These errors are reported in parentheses, below the estimated coefficients. *** p<0.01, ** p<0.05. For a definition of the dependent variables, refer to Table 1.

Table 5: Altered Specifications: Sample selection and Other explanations

	(1) Drop years>1996	(2) All years	(3) Exclude Spot Contracts[b]	(4) Coal protectionism	(5) Utility specific characteristics
PHASE1*POST90	-0.0692	-0.0926**	-0.00509	-0.0237	-0.0337
	(0.0404)	(0.0433)	(0.0220)	(0.0590)	(0.0422)
PHASE1*POST90*MIDWEST	0.214***	0.255***	0.0818	0.174**	0.171**
	(0.0736)	(0.0757)	(0.0494)	(0.0741)	(0.0748)
MIDWEST*POST90	-0.00891	-0.0723	0.0433	0.0147	0.0169
	(0.0372)	(0.0391)	(0.0225)	(0.0376)	(0.0381)
POST90*PROTECT				-0.0318	
				(0.0642)	
Control Variables[a]	Y	Y	Y	Y	Y
Plant and Year Fixed Effects	Y	Y	Y	Y	Y
Utility Fixed Effects					Y
Observations	9,233	11,214	6,365	8,709	8,709
R-Squared	0.115	0.184	0.063	0.110	0.119
Number of Plants	300	305	285	296	296

Notes: The dependent variable in all specifications reported in this table is Z_2. Standard errors clusterd by plant are reported in parentheses under the coefficients. ***$p < 0.01$, ** $p < 0.05$.

a: Control variables include MODES, ACCIDENTS, MINE MOUTH, WEST, INTERIOR, RESTRUCTURE, REPEAT, DEDICATE, DEDICATE_SQUARED, BTU, SULF, and ASH.

b: Spot contracts are defined as contracts with a length less than or equal to 1 year in duration.

Table 6: Considering Length as a Dependent Variable

	(1)	(2)	(3)	(4)	(5)
	SUR Regression		Joint test	SUR Regression	
	Z_2	Length		Z_2	Log Length
PHASE1*POST90	-0.0175	1.071***	7.61	-0.0128	0.179***
	(0.0200)	(0.394)	(0.02)	(0.0196)	(0.0682)
PHASE1*POST90* MIDWEST	0.175***	-1.671***	42.04	0.166***	-0.290***
	(0.0285)	(0.564)	(7.42e-10)	(0.0278)	(0.0969)
MIDWEST*POST90	0.0199	-1.628***	27.54	0.0225	-0.257***
	(0.0158)	(0.312)	(1.05e-06)	(0.0154)	(0.0534)
BTU Z	0.00553			0.00726*	
	(0.00383)			(0.00382)	
Sulf Z	0.00521			0.00317	
	(0.00400)			(0.00385)	
Ash Z	0.00834			0.00394	
	(0.00456)			(0.00434)	
Moist Z	-0.00589			-0.00393	
	(0.00447)			(0.00427)	
Control Variables[a]	Y	Y		Y	Y
Breusch-Pagan Statistic	146.35			292.66	
Observations	6,945	6,945		6,035	6,035
R-Squared	0.418	0.470		0.388	0.444

Notes: *** $p < 0.01$, ** $p < 0.05$. For the definition of Z_2, refer to Table 1. Note the Breusch-Pagan statistic is well above the critical level required to reject the null hypothesis of zero correlation amongst the errors in the pricing and length equation. Column (3) shows the Chi square statistic and p-value following from a joint test of the interaction variables in (1) and (2).

a: Control variables include MODES, ACCIDENTS, MINE MOUTH, WEST, INTERIOR, RESTRUCTURE, REPEAT, DEDICATE, DEDICATE_SQUARED, BTU, SULF, ASH and a full set of year and plant indicator variables.

Table 7: Comparing estimates of Relationship Specific Investment across US coal contracting studies

		Original Study		Current Study[c]	
		(1)	(2)	(3)	(4)
Variable	Definition	In Levels	In Logs	In Levels	In Logs
Joskow 1987					
WEST	Indicator variable that equals 1 if coal is sourced from Western coal region	4.89, 5.89	0.614, 0.684	2.77, 2.99	0.403, 0.445
(+)		(1%), (1%)	(1%), (1%)	(1%), (1%)	(1%), (1%)
MIDWEST	Indicator variable; equals 1 if coal is sourced from Interior coal region	2.42, 3.87	0.515, 0.578	1.60, 2.11	0.212, 0.296
(+)		(5%), (1%)	(1%), (1%)	(1%),(1%)	(1%), (1%)
Quantity[a]	Annual quantity of coal contracted for	0.363, 0.379	0.494, 0.505	0.203, 0.234	0.230, 0.266
(?)			(1%), (1%)	(1%), (1%)	(1%), (1%)
Kerkvliet and Shogren 2001					
Lead Time	Number of years between contract's first announcement and announced year of initial coal delivery	0.582, 0.914	-	Data Not Available	
(+)		(5%), (5%)			
Mine reserve	Tonnage of coal specified over the life of the contract as a proportion of mine's reserves	25.31, 37.75	-	Data Not Available	
(+)		(1%), (5%)			

Table 7 Continued

		Original Study		Current Study[c]	
Variable	Definition	(1) Level	(2) Logs	(3) In Levels	(4) In Logs
Kozhevnikova and Lange 2009					
Quantity[b]	Minimum quantity specified for delivery to the plant (1000 tons)	1.94, 5.7	-	-	-
(+)		(1%), (1%)			
Plant dedicated Assets	Ratio of quantity for individual contract to quantity for the plant as a whole	0.03, -2.08	-	1.61, 1.79	0.211, 0.238
(+)		(), (5%)		(1%, 1%)	(1%, 1%)
Mine dedicated Assets	Ratio of quantity for individual contract to quantity for the mine as a whole	0.19, -0.53	-	0.538, 0.659	0.001, 0.052
(+)		(), ()		(5%), (1%)	(), ()
Current study					
*PHASE1*POST90*MIDWEST*				-1.15, -2.8	-0.29, -0.49
(-)				(1%), (1%)	(1%), (1%)
*PHASE1*POST90*				1.16, 1.99	0.18, 0.35
(+)				(1%), (1%)	(1%), (1%)
*POST90*MIDWEST*				-1.53, -1.90	-0.24, -0.31
(-)				(1%), (1%)	(1%), (1%)

Each cell entry under Columns (1) to (4) contains the highest and lowest magnitude amongst all the specifications reported. The level of significance at which the null hypothesis can be rejected is reported in parentheses under these coefficients. The dependent variable for all specifications is length. The expected sign for each variable is given in parentheses under the variable name. Refer to the text for additional explanation regarding how the estimates shown above are calculated.