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Price Formation and Legal Provisions in Electricity Contracts: An Empirical Study

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ABSTRACT

The paper empirically analyses the effects of legal provisions (setting penalties and incentives, and regulating the parties' obligations and risks) on electricity contracts price formation. Using 27 California long-term electricity contracts for the trade of electricity between generators, we perform an econometric exercise and target the main determinants that affect electricity price. The general result is that provisions increasing (decreasing) the trading risk for the seller, increase (decrease) the price. Those provisions setting penalties (incentives) for the seller decrease the price. These effects are stronger for the contract maximum price. Our 2SLS results can be interpreted in the theoretical framework of transaction cost economics, where provisions regulating risks are set in order to allow for *ex post* adaptation to uncertainty and complexity of transactions and institutional settings. The paper is, therefore, an attempt to endogenize uncertainty and complexity.

Keywords:
electricity contracts, price formation, restructured electricity markets
JEL CODE: C100, L14, L22

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1. INTRODUCTION

Understanding the structure and formation of wholesale pricing in deregulated settings has been of great interest to the researcher in electricity markets. In general, two different electricity pricing techniques can be highlighted: the day ahead auction system (carried on in power exchanges) and the bilateral long-term contracting (see for a survey Borenstein, 1999; Boisseleau and Hakvoort, 2005).

When considering bilateral contracts for the trade of electricity in restructured, wholesale markets, the analysis of negotiation practices, institutional settings and characteristics (and their influence on price formation) has been neglected. To our knowledge, economic theory has been submitted to little econometric testing in this area. In our opinion, therefore, the research gap needs to be explored since "*understanding how and why economic agents use contracts to coordinate their activities is crucial to understanding the organization and efficiency of economic exchange*" (Masten and Saussier 2002, p. 273).

In general, electricity bilateral power purchase agreements have three main dimensions:

1. The electricity selling prices (sometimes distinguished in power and energy);

2. The amount of power and energy sold;

3. A set of provisions that set incentives to improve performance and disincentives to ensure that performance does not fall below a basic standard (see Onofri, 2003).

Following transaction cost economics (TCE), we empirically explore the effects of bilateral contract incentives and disincentives on wholesale electricity price formation. TCE acknowledges the role of contract terms in aligning marginal incentives *ex ante* and in preventing wasteful efforts to *ex post* redistribution of existing surplus. In order to achieve this twofold objective, contract terms have several dimensions that allow the transaction(s) at stake to adapt to the regulated contingencies and circumstances. From this perspective, long-term contracts represent the most effective cost-minimising structure to govern transactions. When uncertainty, complexity and asset specificity[1] are significant, internal organisation (and/or long-term contracts) is likely to be a superior arrangement for governing

[1] Williamson identifies four types of asset-specificity:

- *site-specificity*: once sited the assets are very immobile.
- *physical asset specificity:* when parties make investments in machinery or equipment that are specific to a certain transaction and these have lower values in alternative uses.
- *dedicated assets*: general investment by a supplier or buyer that would otherwise not be made but for the prospect of transacting a specific (large) amount an item with a particular partner. If the contract is prematurely terminated, the supplier (who invested) would be with excess capacity/ the buyer would be with unexpected excess demand.
- *human asset specificity*: workers' acquired skills, know-how and information that is more valuable inside a particular transaction than outside it.

transactions. On the contrary, the market will represent the most efficient form of governance, when uncertainty and asset specificity are not important and transactions are not complex. In this case, contract terms are simple and approximate spot market transactions. According to the TCE approach, the contracting parties involved in a specific relationship use vertical integration and long-term contracts to limit *ex post* bargaining inefficiencies due to hold-up, thereby minimising the resulting loss in *ex ante* investment. This approach predicts a positive correlation between vertical integration (and/or long-term contracts) and the degree of relation specificity. Vertical integration and long term-contracts should enhance both parties' investments positively in the TCE approach.

Electricity restructuring is aimed at introducing competitive dynamics in generation and distribution segments. Regulators worldwide had initially organised electricity transactions in the generation wholesale segment as market (auction) transactions. This auction based governance structure, however, was not sustainable and most of the power exchanges were combined with or substituted by long-term contracts[2]. According to transaction costs theory, profit maximising firms select their governance structure such as to minimise transaction costs. In particular, when exchange involves significant investments in relationship-specific capital, an exchange relationship relying on repeated bargaining is not attractive. "Once the investments are sunk in anticipation of performance, 'hold-up' or 'opportunism' incentives are created ex post which, if mechanisms cannot be designed to mitigate the parties' ability to act on these incentives, could make a socially cost-minimising transaction privately unattractive at the contract execution stage." (Joskow 1987, p. 169). For this reason, long-term contracts that specify the terms and conditions for future transactions ex ante represent a remedy for ex post performance problems. Electricity contracts in restructured wholesale markets are mostly long-term contracts because the activity of generating electricity requires important asset specific investment and a new generator will defer investing in a new plant, until sufficiently long-term contracts are arranged and cover a sufficient portion of the required investment.

On the empirical side, research on TCE has produced testable hypotheses and explained actual contracting practices. Masten and Saussier (2002) survey the most important empirical contributions on the econometrics of TCE, and highlight two main streams of empirical research. On the one hand, the analysis explores the decision to contract, as a standard discrete choice problem, where transactors will choose to contract if the expected gains (net of transaction costs) from doing so are greater than those of organizing the transaction in some other way. On the other hand, researchers mostly focus on the contractual duration problem, where the transactors problem is selecting how many periods their contract should cover, and

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[2] See, for the UK case, from the Pool to the Neta (New Electricity Trading Agreements). For a reference, see Mc Carthy (2000). For a definition of long term contracts in electricity markets, see further, note 5.

the TC determinants affecting contract duration[3].

To our knowledge, the empirical relationship between price formation and institutional/contractual provisions that regulate uncertainty and complexity has not been explored in the literature yet, even though there are some contributions about the relationships between spot markets, forward contract markets, demand and prices in UK electricity restructures markets[4]

The paper's main research question is whether and how contractual provisions, regulating obligations and commitment among the parties, affect the wholesale electricity price in selected long-term, bilateral electricity contracts, stipulated between generators during California electricity crisis in 2001. We operationalize the contracts' main legal provisions in order to perform an econometric exercise and target the main determinants that affect price in long-term electricity contracts.
In particular, we want to test the following two hypotheses:

(1) Those legal provisions that increase (decrease) the trading risk (i.e. uncertainty and complexity of the transaction) will consequently award a more attractive price in return to the party that bear the risk;

(2) Those legal provisions that set incentives (or penalties, in order to adapt to the uncertainty and complexity of the transaction) for one party increase (or decrease) the price.

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[3] A seminal paper about contracts in energy markets is Joskow's (1987) econometric analysis of the duration of nearly 300 coal contracts. Exploiting regional differences in the characteristics of coal and transportation alternatives and variations in contract quantity, Joskow's study shows the duration of coal contracts to be significantly correlated with measures of physical- and site-specificity and dedicated assets. Empirical research in energy markets has also identified a correlation between long-term contracting and specificity in natural gas (Crocker and Masten, 1988) and petroleum coke (Goldberg and Erickson, 1987). Contracting appears less attractive as a way of governing production and exchange, however, where the alternative to contracting is integrated ownership and production. Empirical research on integration decisions reveals a consistent preference for integration over contracting as the specificity of investments increases (see Joskow, 1988; Crocker and Masten, 1996). Contracting thus appears to be only an imperfect response to the hazards posed by relationship-specific investments. Empirical research suggests, moreover, that the costs and limitations of contracting grow with the complexity and uncertainty of the transaction. Goldberg and Erickson (1987) and Crocker and Masten (1988) found that contract duration in petroleum coke and natural gas contracts decreased in periods of increased uncertainty, contrary to what would be expected if risk-sharing were the primary motive for contracting.

[4] Helm and Powell (1992) performed an empirical study of electricity financial forward contracts, which were instituted at privatization between the generators and the regional suppliers in UK. They proposed that the break-up of the first set of "contracts for differences" for electricity led to a structural break in the underlying relationship between the demand for and the price of electricity. They found that this break-up led to a marked increase in prices due to the interdependency between the electricity pool (spot market) and the contract market (forward market). Craig (1997) replicates and augments the work of Helm and Powell by expanding their data set in order to examine the break-up of the second set of contracts for differences in March 1993 and its effects on electricity prices. By utilizing the methodology of Helm and Powell (1992), it is found that the dissolution of this second set of contracts had a similar effect on the relationship between prices and demand. This supports the view that the contract market should be made more open and subjected to more rigorous examination due to its effects on pool prices.

We expect that contractual incentives increase the electricity price and contractual disincentives decrease the price. In addition we expect that contractual adaptation to uncertainty, complexity and asset specificity will positively affect the price the more complex is the adaptation to those contingencies.

The paper is organized as follows: Sections 2 describes the dataset formation, Sections 3 describes the selected model specifications, estimation technique and discusses the estimation results, with the conclusion in Section 4.

2. THE DATASET

The analysis of twenty-seven[5] long-term[6] natural gas and renewable electricity contracts for electricity, signed by the California Department of Water Resources (DWR) on behalf of California's three investor-owned utilities during the 2001 California electricity crisis, forms the basis for the creation of the dataset[7]. From the analysis of each contract, we have selected the main legal and economic provisions and created the variables we needed to perform our econometric study.

The selected contracts contain information about the price at which energy is sold; (setting a minimum and a maximum price range); costs of energy production; quantity of energy produced; contract duration; dispatchability or non-disptachability provisions[8]; type of fuel used to produce energy[9]; type of electricity produced (whether base[10], peak[11], both, summer super peak[12] or intermittent[13]);

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[5] We are aware of the limited amount of analysed contracts. This is due for two main reasons. First, getting such information is very difficult. Second, the economic characteristics of generation electricity market do not allow for the conclusion of a high number of contracts. In a Williamson perspective, in fact, the generation stage of electricity markets is characterized by idiosyncratic relations, need of coordination; asset specificity.

[6] We define long-term contracts as those three years in length or longer. However, long-term contracts can be terminated by the parties before the dead-line. Termination rights by the buyer (CDWR) in some of the agreements include, but are not limited to: (1) failure of a new generation unit to meet commercial operating date deadlines within a specified window; (2) failure to achieve certain operating standards (primarily unit availability) at specified levels for specified periods; (3) failure to operate a generating unit within "prudent industry practice" after notice and opportunity to cure such failure. Termination rights by the seller in some of the agreements include, but are not limited to: (1) Lack of maintenance of investment grade credit; (2) failure by CDWR to issue the bonds contemplated by AB1X prior to a set date; (3) failure to make energy payments within specified days after CDWR's receipt of an invoice.

[7] Although the DWR contracts were not executed in a fully competitive market, the contracts are based on industry-standard contract templates and therefore may provide broader insights into the contractual practices common in competitively bid contracts. The contracts purchase electricity to supply most of the net short of California's three investor-owned utilities, which represents about one-third of the utility customers' power demand.

[8] Non dispatchable contracts (also known as "must take" or "take or pay") require the DWR to pay for, and the seller to provide, all the electricity scheduled in the contract.

[9] In our sample, natural gas, biomass, wind, solar, geothermal, landfill gas.

[10] Baseload contracts (7X24) can supply power all day every day

[11] Peak products (6X16) generally can supply power from 6 a.m. to 10 p.m, Monday through Saturday

[12] Summer super peak products (5X8) generally can supply power for 8 hours per day, 5 days a week, from June through October.

[13] Some electricity generation technologies can only generate electricity intermittently, when the fuel resource is available (e.g. wind and solar).

TABLE 1: VARIABLES DESCRIPTION AND STATISTICS

VARIABLE	DESCRIPTION	MEAN	MIN	MAX	STND DEVI-ATION
MaxPrice **MinPrice**	Maximum Energy Price set in the Contract Minimum Energy Price set in the Contract	131.33 76.59	58 44	379 141	78.93 23.44
Differential	Price Differential Index = (MaxPrice –Minprice)/MaxPrice	0.31	0.04	0.85	0.26
Duration	Contract Duration in years	8.92	3	20	4.26
Total Quantity	Contract Total Quantity (GWh)	21648.26	112	93325	27239.44
Costs	Contract Total Power Production Costs (in Million $)	1493.25	7	6238	1699.421
Tolling Payment **Fixed Payment**	Contract Payment Type Contract Payment Type. Dummy Variables	D = 1; 16 Observations D = 1; 11 Observations			
Fuel Supply Risk	Provision regulating the risk that fuel supply to a power plant will be unreliable Dummy Variable	D = 1; 9 Observations			
Take-or-Pay Contract	Provision requiring the seller to provide all the electricity scheduled in the contract. Non Dispatchable Contract. Dummy Variable	D = 1; 11 Observations			
Construction Incentives	Provision that create incentives for the seller for reaching operation by dead-line Dummy Variable	D = 1; 17 Observations			
Construction Penalties	Provision that obliges the seller to pay for not reaching operation by dead-line Dummy Variable	D = 1; 10 Observations			
Availability Incentives	Incentive for availability Dummy Variable	D = 1; 14 Observations			
Availability Penalties	Contractual Availability Penalties. Dummy Variable	D = 1; 13 Observations			
New units	Provision that signals whether the contract provides for the construction of new power units. Dummy Variable	D = 1; 17 Observations			
Environmental Regulation	Provision about environmental risk, stemming from both existing environmental regulations and possible future regulations. Dummy Variable	D = 1; 7 Observations			
Prevent Regulation	Provision regulating the risk that future laws or regulation, or regulatory review of a contract, will alter the benefits or burdens of an electricity contract to either party. Dummy Variable	D = 1; 13 Observations			
Fuel Supply Risk	Provision that excuses the seller from delivering power if fuel supply is interrupted. Dummy Variable	D = 1; 9 Observations			
Natural Gas **Wind** **Biomass**	Electricity Generating Resource Electricity Generating Resource Electricity Generating Resource Dummy Variables	D = 1; 18 Observations D = 1; 2 Observations D = 1; 5 Observations Other Source: geothermal energy			
Base **Peak**	Electricity Type of Product Electricity Type of Product Dummy Variables	D = 1; 13 Observations D = 1; 7 Observations Other contracts produce intermittent or both base and peak power			

type of pricing mechanism (tolling[14], or fixed price[15]); provisions about how to manage risk (fuel price risk[16]; fuel supply risk[17]; performance risk[18]; demand risk[19]; environmental risk[20] and other type of risk[21]). Table 1 summarizes the main contractual provisions. A peculiarity of the contracts is that it was not possible to identify a common structure or an empirical regularity. For instance, gas fuelled plants can sell electricity using either a tolling or a fixed price agreement; either dispatchable or non-dispatchable contracts.

The econometric exercises' dependent variable is the contractual price per MWh for the supply of the contracted amount of energy. Table 1 describes the selected variables and provides descriptive statistical analysis.

A *caveat* needs to be highlighted. The market structure, within which the DWR, electricity contracts were negotiated, was a deregulated, partially competitive market, where most electricity transactions were carried on an anonymous power exchange, where the participants bids "quantity-price schedules" for every half an hour of the following day[1] and where the resulting electricity wholesale prices (for each half hour of the following day) are equilibrium prices derived from an auction bidding procedure. The DWR contracts electricity prices are wholesale prices, negotiated in long term bilateral markets. In addition, the DWR contracts were stipulated during the electricity crisis, when long term-contracts were used as an instrument to secure supply reliability and lower electricity prices.

Even though 2001 electricity shortages might have given some more negotiation power to sellers, this does not imply that the selected contracts are regulated or administered contracts (in a Goldberg framework). DWR are market contracts which contain terms and conditions that are representative of the electricity market as a whole[22]. We can interpret the 2001 particular market conditions in a Williamson framework, as events that increased uncertainty and complexity of the negotiation process. DWR contracts, however, are not regulatory contracts, but market contract. A clear example of this statement is a provision contained in the *Allegheny Contract*: **"***if a Regulatory Authority orders a change in the contract, the price will not change"*.

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[14] The buyer pays for the cost of the resource used to produce electricity, pays the generator a fee to reserve the use of the facility and pays operating charges when the facility generates power.

[15] The contract price per MWh is set in the contract.

[16] The risk that the price of the fuel used to generate electricity will exhibit variability (positive or negative) resulting in an uncertain cost to generate electricity.

[17] The risk that the fuel supply to a power plant will be unreliable, resulting in the inability to generate electricity in a predictable and dependable manner.

[18] The risk that either party to an electricity contract will not fulfil its part of the agreement in an optional manner.

[19] The risk that the electricity that has been contracted for will not be needed as anticipated.

[20] The financial risk to which parties to an electricity contract are exposed, stemming from both existing environmental regulations and possible future regulations.

[21] The parties to an electricity contract face numerous other sources of uncertainty (i.e. the risk that the transmission system will be unreliable: or the risk that a party to the contract will default on the contract, by entering into bankruptcy).

[22] Competitive dynamics refers to the fact that parties have adopted industry-standard contracts from Edison Electric Institute and Western Systems Power Pool. Both parties had incentives to sign contracts; DWR contracts are not regulated contracts. Both sides used experienced contracts negotiators.

Therefore, "*Although the unique conditions surrounding the DWR contracting process may have yielded some contracts executed in a hurry that are more favourable to the Seller as well as average prices that are higher than the "norm," as a whole the terms and conditions of the DWR contracts can provide insight into the risk allocation and mitigation practices common in the electricity industry*" (Bachrach, 2002, pp 8).

3. Endogeneity Problem of Contractual Provisions and 2SLS Estimation Results

The paper's main research question is whether and how contractual provisions, regulating obligations and commitment among the parties, affect the wholesale electricity price in selected long-term, bilateral electricity contracts.

We want to test the following two hypotheses:

(1) Those legal provisions that increase (decrease) the trading risk (i.e. uncertainty and complexity of the transaction) for the seller will increase the contract price;
(2) Those legal provisions that set incentives (or penalties, in order to adapt to the uncertainty and complexity of the transaction)) for the seller increase (or decrease) the price.

We expect that contractual incentives increase the price and contractual disincentives decrease the price. In addition we expect that contractual adaptation to uncertainty, complexity and asset specificity will positively (negatively) affect the price the more (less) complex is the adaptation to those contingencies.
More formally, we can define the electricity price function as dependent on two main groups of variables: technological and economic variables and institutional variables that regulate other transactional dimensions (mostly uncertainty, complexity and asset specificity).

(1) Price = f[Costs(Production Inputs, Technology); Traded Quantity; Asset Specificity; Uncertainty; Complexity)].

The hypotheses reflect the general theory that contract terms both align *ex ante* marginal incentives and prevent wasteful efforts towards *ex post* redistribution of existing surplus. In the case at study, electricity contract provisions have both to secure sufficient reliability (for instance, by setting monetary or non-monetary incentives to production availability) in order to allow the contracting parties (in particular the Seller) to adapt to contingencies that might ex post vary due to uncertainty and complexity of transactional settings.

In order to empirically capture and operationalise the relationships between long term contracts electricity price and contractual provisions that enable efficient adaptation to uncertainty and complexity, through risk allocation, we have to make some distinctions about the "nature" of contractual provisions. We assume that some contract provisions (like production capacity or the electricity production inputs) are determined before parties determine contract price. That is, such contract provisions are "predetermined variables", and therefore can be treated and interpreted as exogenous variables in the estimation of the relationship between contractual provisions and contract price[23].

Saussier (2000) highlights that many empirical attempts to refute transaction cost economics ignore the possible endogeneity of asset specificity, uncertainty and complexity when testing the heuristic transaction cost model, or avoid the endogeneity problem by estimating a reduced-form using proxies to reflect asset specificity (or uncertainty and complexity) levels at stake in transactions. These approaches can be surpassed by taking into account the endogeneity of several explanatory variables, in what is known as the limited-information approach. To our knowledge, no econometric test has yet tried to endogenize complexity and uncertainty at stake in transactions[24].

Our problem, therefore, boils down to estimating a price function, where crucial variables are represented by provisions that allow adaptation to uncertainty and complexity. In our framework:

$$(2)\ \ Price = f(\underset{(+/-)}{Adaptation\ to\ Uncertainty};\ \underset{(+/-)}{Adaptation\ to\ Complexity}).$$

In this perspective, the price of electricity contracts (also) depends on the way provisions regulate adaptation to uncertainty and complexity of the transaction. The expected sign of estimated coefficients can, therefore, be positive or negative.

After several checks, we select a simple linear specification and estimating it by 2SLS method.

$$(3)\ (Min, Max, Average)Price = a_i + \beta Y_i + \gamma Z_i + \varepsilon_i$$

We attempt to estimate three different dependent variables *Minprice* (contractual minimum energy price); *Maxprice* (contractual maximum energy price) and *Average Price* (the arithmetic average of the former prices[25]).

In (1), Yi indicates the endogenous variables, including terms of contract, and $Z\grave{i}$ indicates instruments. In particular, we estimate a simultaneous equation model where the selected instruments (plant capacity; electricity product; production costs; fuel type and other technical indications) represent variables determined before contracting.

The selected endogenous variables (*Duration*; *Environmental Regulation; Prevent Regulation; Availability Incentives; Fuel Supply Risk*) represent provisions that are jointly determined within the contract and that are jointly determined with the contract price structure, in order to allow for contingent adaptation to risks generated by

[23] See Green (2000), pag.656-657.

[24] . Saussier (2000) and Onofri (2008) papers are attempts to endogenize asset specificity in transactions.

[25] The maximum and minimum price were modelled because e.very contract indicates a maximum and a minimum price range for electricity. These are available data. We are aware, as pointed out by a referee that we are considering the pricing range extreme bounds. In order to (partially) overcome the problem, we have calculated the arithmetic average price.

uncertainty and complexity of the transaction at stake. The 2SLS estimates are reported in Table 2[26].

TABLE 2:
2SLS ESTIMATION RESULTS

Dependent Variable / Independent Variables	Minimum Price	Maximum Price	Average Price
Duration	-38.24*	-12.34**	-12.94**
Environmental Regulation	39.83***	311.80*	175.82*
Prevent Regulation	-0.54***	-64.20*	-32.37*
Availability Incentives	10.09***	184.07*	97.08*
Fuel Supply Risk	-12.47***	-80.36*	-46.41*
Constant	98.49*	168.60*	133.55*

* = 5% statistically significant estimated coefficient
** = 10% statistically significant estimated coefficient
*** = 25% statistically significant estimated coefficient

Table 2 reports selected 2SLS estimation results, when the dependent variables are the contract *minimum price, maximum price* and *average price.* In general, it is interesting to remark that the estimated coefficients for those provisions regulating adaptation to uncertainty and complexity of the transactions (i.e. performance, risks and "*force majeur*") are statistically significant when the dependent variable is the *maximum price*. The variables that affect the formation of the minimum price appear less related to risk issues/adaptation to contractual uncertainty and complexity.

The longer the contract, the lower the price - however estimated coefficients for *Duration* are statistically significant only when the minimum price is the dependent variable.

The estimated coefficients for "*Environmental Regulation*" are positive and statistically significant (when the dependent variable is the maximum and average price). Electricity contracts have very different environmental risk profiles by nature of the technologies and fuel sources used to generate the electricity. If new environmental regulations are enacted, the seller (in particular for non-renewable contracts) will most likely have to bear additional costs. This might positively affect the electricity price.

The estimated coefficients for "*Prevent Regulation*" are negative and statistically significant when the dependent variable is the maximum and average price. This group of provisions regulate the risk that future laws or regulation will alter the benefits or burdens of an electricity contract to either party. *Ex ante* adaptation to the uncertain contingency of prevent regulation, implies setting a lower (maximum

[26] Our econometric exercise was performed using STATA, which has the advantage to signal any identification problem.

and average) price. This effect should probably be explained in view of a future, sudden termination of the contract upon the (*ex ante* uncertain) occurrence of regulatory intervention in the electricity market.

The dummy variable "*Availability Incentives*[27]" presents positive, statistically significant estimated coefficients when the dependent variable is the maximum and average price. Since the seller builds and operates the power plant (that provides the electricity sold under a contract), the seller is best able to control the performance of the power plant. For this reason, the contracts allocate a substantial amount of performance risk to the seller, and provide incentives for the seller to perform in a way that reduces the uncertainties faced by the buyer (DWR).

The estimated coefficients for "*Fuel Supply Risk*" are negative and statistically significant when the dependent variable is the maximum and average price. Fuel supply risk is the variable signalling that the contract contains a provision that excuses the seller from delivering power if fuel supply is interrupted. Fuel supply risk is the risk that the fuel supply to a power plant will be unreliable, resulting in the inability to generate electricity in a predictable and dependable manner. When such provision is contained in the contract, it negatively affects the (maximum and average) price, because it renders the transaction less risky for the seller. In this way, the buyer is compensated for an increase of the contractual transaction by paying a lesser price.

4. CONCLUDING REMARKS

The paper has empirically analysed the effects of legal provisions setting penalties and incentives, and regulating the parties' obligations and risks, on electricity contracts price formation. We have selected 27 California long-term electricity contracts for the trade of electricity between generators. We have created a dataset by using the contracts' main legal provisions, in order to perform an econometric exercise and to target the main determinants that affect price provisions in long-term electricity contracts. The general result is that the provisions increasing (decreasing) the trading risk for the seller increase (decrease) the price; those provisions setting penalties (incentives) for the seller decrease the price. A peculiarity is that the legal provisions regulating obligations and risks and setting incentives and penalties mostly affect the maximum contract price. 2SLS estimated coefficients for legal provisions are not statistically significant when the dependent variable is the minimum price. Our results can be interpreted in the theoretical framework of TCE, where provisions regulating risks are set in order to allow for *ex post* adaptation to uncertainty and complexity of transactions and institutional settings. The paper is, therefore, an attempt to endogenize uncertainty and complexity.

Since the paper is, to our knowledge, one of the first attempts to empirically model and capture institutional effects on price formation, further research should

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[27] The general definition of availability is the number of hours that the generation unit is *available* to generate power during a period, divided by the total possible number of hours the unit could have been dispatched during the period as specified in the contract (adjusted for *force majeure* events and scheduled outages). Contracts also provide the seller an incentive to surpass the guaranteed level of availability. Most of the contracts guarantee availabilities over 95% during the summer and over 90% during the rest of the year.

continue on the way to operationalize and embody in regression lines institutional variables.

Williamson's advice (1993, p. 27) is worth quoting: '*To be sure, there is much to be done, hence there is no basis for complacency…most (empirical studies) are regressions in which asset specificity (and sometimes uncertainty and frequency) appear as independent variables'. This point requires urgent attention in the development of empirical tests of the theory*".

APPENDIX

SOME EXAMPLES OF ELECTRICITY CONTRACTS SELECTED LEGAL PROVISIONS[28]:

1. Provisions that regulate Fuel Supply Risk:

a) ***Fresno Cogeneration Contract***: the Seller is excused from delivering power if fuel supply or fuel transportation is interrupted except if the interruption is due to Seller's negligence.
b) ***Calpeak Contract***: the Seller is excused from delivering power if fuel supply or fuel transportation is interrupted except if the interruption is due to non-economic reasons.
c) ***PacificCorp Contract***: the Seller is excused from delivering power if fuel supply or fuel transportation is interrupted, except if the interruption is due to *force majeure* in fuel supply or transportation agreement.
d) ***Clearwood Contract***: the Seller is excused from delivering power if fuel supply or fuel transportation is interrupted except if the interruption is due *force majeure*, that include inadequate or excessive geothermal reservoir pressures or temperatures.

2. Provisions that forecast and adapt to the occurrence of Electricity Market Regulation:

a) ***Allegheny Contract***: if a Regulatory Authority orders a change in the contract, the price will not change.
b) ***Sempra Contract***: if a Regulatory Authority orders a change in the contract the adversely affected party may terminate or re-negotiate the contract.
c) ***Coral Power Contract***: if a Regulatory Authority orders a change in the contract the Seller can terminate the contract (with no termination payment).

3. Provisions that forecast and adapt to the occurrence of Environmental Regulation:

a) ***Calpine Contract***: any cost above a certain threshold ($5/MWh), generated by a future environmental regulation imposed by a governmental authority, is born by the Seller.
b) ***GWF Contract***: the costs generated by environmental regulation are renegotiated in good faith, but the Seller may terminate the contract.

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[28] Source: Bachrach D. (2002)

4. **Provisions that regulate Availability Incentives and Penalties:**

   a) ***Capitol Power Contract*****:** if the plant does not meet availability guarantee for 3 consecutive months, the Buyer can terminate.
   b) ***Alliance Colton Contract*****:** the Buyer can terminate if annual average availability is less than 60% for any two out of three years. If the Seller fails to meet availability guarantee intentionally, then Seller defaults.
   c) ***Wellhead Contract*****:** the Buyer can terminate if the availability is less than 60% for one year.

5. **Provisions that regulate Power Plant Construction Incentives and Penalties:**

   a) ***Sempra Contract***: if the unit fails to reach operation despite Seller's reasonable effort, Seller is not liable to provide electricity.
   b) ***Sunrise Contract***: the Buyer can terminate the contract with respect to any unit that does not reach operation by dead-line**.**
   c) ***High Desert Contract*****:** the Seller pays the Buyer a penalty for not reaching operation by dead-line.

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