



Determinants of contract completeness: An environmental regulatory application



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ABSTRACT

There is a tradeoff that must be addressed any time a contract is written; whether or not to make a contract flexible but incomplete or rigid but comprehensive. This paper investigates the completeness of hydroelectric license contracts over a nearly three decade time span and finds that as environmental concerns increase, so does contract flexibility, ultimately confirming the predictions of transaction cost theory. The paper offers an interesting historical look at the development of the U.S. hydroelectric dam license as it ages over time and responds to growing environmental concerns. It also, in a novel empirical application, combines traditional regression analysis with insights from textual analysis and computational linguistics.

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1. Introduction

There is a tradeoff that must be addressed every time a contract is written; whether or not to make a contract flexible but incomplete or rigid but comprehensive. A flexible contract allows room for adaptation to future unforeseen circumstances, but at the same time allows for potential opportunism by the contracting parties as states of the world evolve. This paper investigates the factors that determine the degree of flexibility chosen in a long-term contract to balance these competing concerns.

The fact that contracts exist at all in a market-based free exchange system was first elaborated on by Coase in his classic 1937 paper *The Nature of the Firm*, where he explained the existence of vertical integration of exchange, from contracts to mergers all the way up to government production, as a result of transaction costs. Over the years other seminal authors have operationalized the factors that underlie transaction costs, including asset specificity, uncertainty, duration, and probity (Klein et al., 1978; Williamson, 1979, 1999), while others have attempted empirical tests of the theory (Joskow, 1987, 1990; Crocker and Masten, 1988, 1991; Crocker and Reynolds, 1993; Saussier, 2000; Kerkvilet and Shogren, 2001; Neumann and von Hirschhausen, 2008; Kozhevnikova and Lange, 2009). A look through the literature, however, fails to uncover papers that have tested contract completeness per se. Data

limitations have generally led to indirect or partial tests of contract completeness. This paper utilizes a unique dataset on U.S. hydroelectric license contracts that spans over 30 years, and tests whether the factors suggested in transaction cost theory indeed influence the actual completeness of a given contract.

The contributions of this paper are 3-fold. First, it is a direct empirical test of contract completeness based on the theoretical predictions of transaction cost theory. Second, it offers an interesting historical look at the evolution of hydroelectric license contracts as they respond over a 30 year time span to changing environmental conditions and morphing societal welfare functions. And finally, and perhaps most novel empirically, this paper arrives at its results through a combination of traditional regression analysis and computational linguistics, including textual analysis, word clouds and new forms of digitized quantitative analysis that are only just beginning to be utilized in the wider academic literature (Grimmer and King, 2010; Michel et al., 2011; Evans and Foster, 2011).

The results indicate that hydroelectric license contracts have grown more flexible over the last three decades, confirming the general predictions of transaction cost theory. As environmental uncertainty regarding the implications of hydroelectric power production has increased, so too has the incompleteness and flexibility of hydropower license contracts. In the tradeoff between flexibility and rigidity, flexibility has won out as environmental concerns have dominated asset-specific hold-up fears. The regression results provide the primary evidence for this result, though the textual analysis appears to confirm it as well. Textually, when assuming contract flexibility is mirrored in increasing average

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sentence lengths, near identical results to the regression analysis are uncovered. A cursory investigation into the frequency of the words themselves fails to show support for increased use of *particularly* flexible words, however, this result appears to highlight the importance of clear contractual terms stating contract flexibility, rather than subtle word choice changes that could, in fact, be prone to future legal misinterpretation anyway. Ultimately, the results provided in this paper provide direct evidence that the relative completeness of a given hydroelectric license contract can be explained by such transaction cost theory based factors as uncertainty, duration, and reputation.

The rest of this paper is organized as follows: in Section 2 an extended literature review is given that covers both the history of transaction cost theory, as well as recent academic work involving textual analysis. In Section 3, the model and primary hypotheses are developed. Section 4 gives background on the hydroelectric license contracting process, Section 5 presents the data, Section 6 the results from the regression and textual analyses, and Section 7 concludes.

2. Literature review

The early literature on contract design was pioneered by Coase (1937) who mulled over the rational existence of the firm in a world of free market-based exchange. He came to the conclusion that firms exist because the vertical integration of exchange they embody can save on costs; in other words, it may be cheaper to produce some items within a firm than through a series of individual market-based exchanges. Goldberg (1976) added a vociferous justification of such vertical integration, all the way up to the government level, when the difficulties embodied in production are so great they may be inherently unmanageable any other way. Klein et al. (1978) and Williamson (1979, 1999) began the task of operationalizing the key variables that led to the need for some form of vertical integration, be it at the firm or government level. Klein et al. (1978) in particular stressed the hold-up problem, where one party to an exchange makes production-related investments whose value is tied to the exchange relationship proceeding, but then finds that the other party may try to take advantage of the situation by holding up production and expropriating production related rents. Williamson (1979, 1999) identified other key factors, including the uncertainty and complexity of the trading environment, the time duration of the exchange relationship, and the probity of the production good under consideration. These four categories – asset specificity, uncertainty, duration, and probity – are the primary categories of transaction costs that are regularly referred to when discussing transaction cost theory and its effects on contractual exchange relationships.

There are a number of predictions that stem from this work on transaction cost theory, including that as the asset specificity embodied in a contract increases, the rigidity or completeness of the contract should increase as well in order to protect the parties from any potential hold-up problems in the future. Another prediction is that as the uncertainty surrounding a contracting environment increases, so too should the ultimate flexibility (or incompleteness) of a contract in order to allow for an efficient response to unexpected, unfolding states of the world. Similarly, as the duration of a contract increases, the prediction is that flexibility should also increase in order to allow for efficient responses to increasingly distant and unknown future states of the world. And finally probity implies that contracts can be written with greater flexibility as the contracting parties increasingly trust one another.¹

Empirically, these specific hypotheses have not been subject to robust tests in the literature. To date, the empirical literature on transaction cost theory has primarily investigated tests of contract duration. For example, Joskow (1987), Crocker and Masten (1988), Kerkvilet and Shogren (2001), Neumann and von Hirschhausen (2008), and Kozhevnikova and Lange (2009) have all utilized contract duration as the dependent variable and tested whether or not contract length is affected by things such as asset specificity, degree of opportunism, and degree of regulatory interference. The context of these empirical tests varies from coal to natural gas, but the duration dependent variable remains consistent. A few studies do exist which get closer to literal tests of contract completeness (Joskow, 1990; Crocker and Masten, 1991; Crocker and Reynolds, 1993), but the dependent variables in all of these studies relies heavily on pricing provisions. Pricing provisions for exchange of the good in question is only one possible aspect of contract flexibility. Using pricing provisions alone to test for contract completeness in a comprehensive sense is specious. The only empirical study in the literature that the author is aware of which tests for contract completeness with a dependent variable that is more broadly based is Saussier (2000). The main problem with this study, however, is that the empirical results are based on just 29 observations, which is a rather small sample size. This paper appears to be the first in the literature that tests the flexibility/completeness predictions of transaction cost theory with a dependent variable that measures direct flexibility contractual provisions. The results are then given an additional empirical check with textual analysis and other computational linguistic techniques.

Textual analysis involves the accumulation of a large amount of text (from digitized books, online message boards, or twitter feeds, for example), cleaning and parsing the text with unique algorithms, and then turning the text into a database where the words themselves are statistically analyzed for trends and correlative patterns (Grimmer and King, 2010; Michel et al., 2011; Evans and Foster, 2011). Text analysis is a part of the larger Big Data revolution that is currently underway due to the explosive availability of data in recent years. Creative researchers from such disparate fields as psychology, medieval literature, and finance have mined resources that include Google clicks (Choi and Varian, 2009), twitter feeds (Bollen et al., 2011), and YouTube videos (Patel et al., 2009; Schachner et al., 2009) to investigate a wide range of behavioral and historical questions. Textual analysis is one particular form of analysis this new data deluge allows and which is the focus of this paper.

Interesting examples of recent textual analyses include an investigation of culture from Top Ten song lyrics (DeWall et al., 2011), gender identification in literary styles (Koppel et al., 2011), media slant in newspapers (Gentzkow and Shapiro, 2010), and bargaining power in US-American Indian treaties (Spirling, 2010).

For the most part, published academic studies involving textual analyses have been in the humanities, political science, and computer science fields. While there have been a few notable finance papers, such as on the ability of stock message boards to predict the Dow Jones Industrial Average (Antweiler and Frank, 2004) and the effect of negative words in the *Wall Street Journal* on stock market returns (Tetlock, 2007), and some entertaining non-academic economic analyses (Krugman, 2011; Gerow and Keane, 2011), as far as this author is aware, textual analysis in the law and economics literature more broadly is still very much in its infancy. This paper appears to be one of the first to utilize textual analysis as a significant methodological component in its empirical analysis. There is not, therefore, a body of previous literature to cite that

¹ Probity was initially highlighted in its relation to government-based contracts, but in a more general sense it is related to integrity and reputation, which has

been stressed as an important determinant of contractual outcomes in, for example, Banerjee and Duflo (2000).

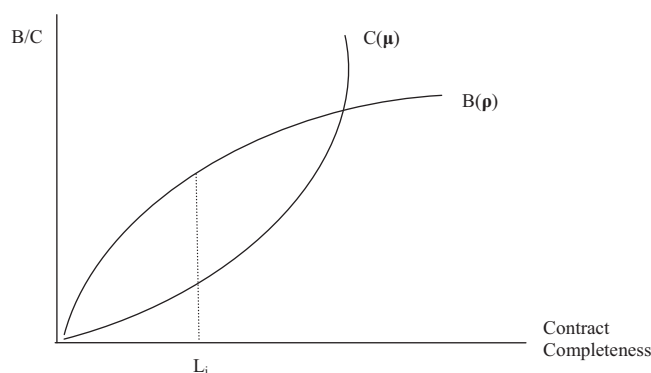


Fig. 1. The contracting completeness decision.

can inform the textual assumptions and predictions, instead, they are developed within the context of this paper.

3. Model

The level of completeness embodied in a given contract, i , depends on the tradeoff chosen between contract flexibility (which allows parties to respond more efficiently to events as they unfold in the future) and the potential for opportunism (which stems from the hold-up problem elaborated on by Klein et al., 1978). This can be represented, as in Fig. 1, as a benefit-cost tradeoff calculation that results in a given level of contract completeness, L_i .

Specifically, the benefit curve depends on a vector of characteristics, ρ , that indicate the degree of asset specificity involved in a contracting relationship. It includes large capital costs, human capital investments, and geographic specificity that make the trading partners reliant on each other and subject to potential rent extraction from opportunism later. The higher the level of asset specificity, the greater the value of the benefit from contract completeness due to reduced opportunism later. This is why the benefit curve is increasing but at a decreasing rate. Should the overall level of asset specificity in a trading environment increase (decrease), this would cause a pivot of the benefit curve and a subsequent increase (decrease) in the level of contract completeness, L_i .

The cost curve depends on a vector of characteristics, μ , that indicate the measure of uncertainty inherent in a contracting environment. They include such things as product quality uncertainty, political regulatory uncertainty, and technological and environmental uncertainty. The more complete a contract (the higher the level of L_i), the greater the contracting costs from these variables will be, as there will be less room for flexible responses to them as the contract plays out. This is why the cost curve is increasing and at an increasing rate. As well, should the level of uncertainty embodied in these factors increase (decrease), this would cause a pivot of the cost curve and a subsequent decrease (increase) in the level of contract completeness, L_i .

This model of the contracting completeness decision results in the following testable hypotheses:

Hypothesis 1. As the uncertainty in a contracting environment increases (decreases), the level of contract completeness should fall (rise).

Hypothesis 2. As the asset specificity in a contracting environment increases (decreases), so too should the level of contract completeness.

These two hypotheses relate directly to predictions from transaction cost theory. Transaction cost theory, however, also has something to say about duration and probity, namely, that as the duration of a contract increases, the level of contract completeness

should fall, and that as the probity implicit in a contracting environment increases, the level of contract completeness should fall. These two additional predictions can be embodied in the hypotheses stated above. Duration in a hydroelectric licensing contract, as will be described below, is determined in a perfunctory manner on capital costs, therefore in this context in particular, duration is akin to asset specificity, which implies a direct relationship to Hypothesis 2. Probity, in this context, can be interpreted as reputation and a strong reputation, the literature suggests, reduces uncertainty. Probity, therefore, is akin to certainty, which implies a direct relationship to Hypothesis 1. In this paper's particular empirical context, therefore, one can test the four traditional operationalizations of transaction cost theory (asset specificity, uncertainty, duration, and probity) as embodied in the two hypotheses stated above.

4. Hydroelectric license contracts

In the United States today there are approximately 84,000 dams.² These dams serve a variety of purposes, including flood control, irrigation, navigation, and recreational purposes. Less than 4% of these dams, or only about 3000 in total, support hydroelectric production.³ These hydroelectric dams have a variety of owners, including the federal government, non-federal public municipalities, private utilities, private generation companies (also called “non-utilities”), private industrial owners, and electric cooperatives. All dams not directly owned by the federal government (i.e. “nonfederal”) must be periodically licensed by the Federal Energy Regulatory Commission (FERC) in order to legally operate. This licensing process evolved in the early 20th century in response to the tradeoff posed in constructing large hydroelectric dams. Traditional hydropower dams have large fixed costs, which, by definition, require a number of years of positive revenues in order to recoup. At the same time, hydropower dams are, by necessity, built along public streams and rivers over which the public likes to maintain a degree of control. In the early 20th century the country was growing rapidly and new sources of power to satisfy its mounting energy needs were in great demand. The government sought to encourage hydroelectric power production, but private investors were hesitant to build without assured control of their assets. The conundrum in Congress, therefore, was how to encourage private hydroelectric power development, while at the same time not relinquishing societal input and ultimate control over the nation's river systems.

In 1920 Congress passed the Federal Water Power Act (FWPA), the first piece of legislation to formally institutionalize the hydropower licensing responsibilities of FERC.⁴ It achieved a balance between public and private objectives by creating lengthy licensing terms of at least 30, but not more than 50, years. Essentially, all nonfederal hydropower dams became subject to intense public oversight once every 30–50 years, but after they were licensed, they were essentially left alone from new contracting authority for decades at a time. This was considered sufficient to maintain a degree of public control over the river system, while at the same time allowing enough independence to encourage private hydropower development.

The licensing process initially instituted by FERC had a well-defined procedural schedule (FERC, 2004), involved the dam owner and public interest groups in the input process, and resulted in a

² As documented by the National Inventory of Dams: <http://geo.usace.army.mil/pgis/f?p=397:1:1670802410045182::NO::>

³ Either as the sole purpose of the dam, or as an ancillary purpose to something else, for example, flood control.

⁴ Which, at that time, was called the Federal Power Commission (FPC).

formal contractual license that was in effect for 50 years for brand new dams, 30 years for relicenses of existing dams, and 40 years for relicenses of existing dams that had undergone major capital improvements.⁵ The duration of a license varied little within these set 50, 40, or 30 year parameters,⁶ and licenses themselves were almost always issued once a project had begun construction. In the dataset this paper covers (all licenses and relicenses issued by FERC between 1977 and 2007), approximately 14% of the observations are for original licenses, while the vast majority are for relicenses.⁷ Of the 1343 projects to have come up before FERC over this time span, only one was ever denied. In other words, the dataset does not suffer from bias due to observations that never completed the licensing process – nearly all projects that come before FERC *do* get a new license. The licensing process is not pro forma, however, it is a complex and at times contentious process, but that is because of what goes *into* a license, not because there is generally a great deal of debate over whether or not to issue a license at all.

It is worth noting that FERC's role in the licensing process is as arbiter of the negotiations and enforcer of the final licensing contract. They are the umpire in this ball game, not an independent team. The teams are the stakeholders, including the dam owner and associated investors, and interest groups concerned with the river and public resources.

The issues that are generally debated in a licensing application have changed over time. Early in FERC's licensing days, the important points over which licenses varied concerned safety and structural integrity issues of the dam, its electric power facilities, and the reservoir. Rarely were environmental concerns over water quality, ecosystem management, esthetic appearances, and other more contemporary environmental issues considered. This began to change in the 1980s as the modern environmental movement in the U.S. gained momentum. Beginning in the 1980s, when nonfederal dams came up for licensing, the debate increasingly emphasized environmental management issues, reflecting society's changing preferences for more environmental protection. Research in the law literature suggests this change may have been accompanied by increasingly flexible license provisions (Pollak, 2007). Safety concerns are relatively straightforward and can be addressed by closed-ended provisions targeting engineering and technical integrity checks. Environmental issues, however, are more complex. The biological processes behind many environmental factors are still poorly understood, and adequately protecting things like fishery resources and water quality is difficult to implement at best. Adaptive Management, a common methodological tool for implementing environmental protection measures, is by definition based on flexibly responding to the changing and unpredictable biological requirements of an ecosystem over time. At first blush, therefore, one would expect hydroelectric power licenses to have become increasingly flexible over the past 30 years in response to the increasing emphasis on environmental issues, but this is not the end of the story.

An understanding of transaction cost theory tells us that uncertainty (biological or otherwise) is only one factor that can affect contract completeness. Asset specificity, in particular, is another important determinant and hydropower projects in particular involve significant levels of asset specificity. Hydropower dams

are large, capital intensive, immovable projects that imply a substantial degree of illiquid investment on the hydropower owner's part. Indeed, the marginal costs of hydropower production and management are relatively minor compared to the large costs of hydropower plant construction, including the dam and the power generation facilities. Hydropower owners, then, would be expected to push for a high degree of contract completeness in any specific licensing procedure in order to avoid the rather significant hold-up problems that could occur later.⁸

In essence, therefore, there are conflicting motivations in the hydropower licensing process concerning contract completeness, and they stem primarily from asset specificity on the dam owners' side, and biological uncertainty on the environmental side. These conflicting motivations would imply that the level of contract completeness in any particular licensing application is dependent on the tradeoff between these two forces. In the following empirical section the level of actual contract completeness in hydropower license contracts from the last 30 years is investigated.

5. Data

The data come from a number of sources. The primary information on hydropower projects comes from a FERC maintained database, the Hydropower Resource Assessment database, or HPRA. It lists all the hydropower projects that have been licensed or relicensed by FERC since its inception in 1977.⁹ The HPRA includes not just a list of project numbers, but a range of key descriptive characteristics for each of the projects listed including, for example, dam height, project owner, and physical location of the project. It is from this dataset that most of the variables which represent asset specificity are acquired. Specifically, *kW* measures the available kW production capacity at a project. *Multiple Dams* is a dummy variable indicating whether a project (and thus a project license) is composed of more than one hydroelectric dam. The majority of projects consist of only one dam (83%), but there are some projects that are large, sprawling facilities with multiple dams and these receive a positive *Multiple Dams* value. *Max Dam Height*, measured in feet, is a measure of the tallest (if there is more than one) dam on site. *Plant Type* is a dummy variable indicating whether a project is a run-of-river facility. Run-of-river facilities (as opposed to peaking facilities) are restricted to generating power as the river flows, rather than at peak times of day when energy demand (and thus energy prices) are highest, and are therefore less profitable. As run-of-river facilities have less financial value they may be viewed as having less asset specificity. And finally, the following geographic variables: *Portland*, *San Francisco*, *Atlanta*, *New York*, and *Chicago* are included. These are the locations of the five regional offices of FERC and there is no real organizational difference between them, but they do process the paperwork and license filings for the projects within their district (Fig. 2), and as such serve as a convenient indicator variable for geographic region.

The next set of variables is designed to test for environmental concern, or uncertainty, in a licensing process. They include *Wild Scenic*, which indicates whether the river upon which the project is built has been listed under the federal Wild and Scenic Rivers Act of 1968 anytime before (and including) the year in which the project filed for a new license. *Endangered Species* is a count of the

⁵ Note that FERC serves as the arbiter of this licensing process, not in any way as a rights holder to the dam, the waterway, or anything involved in the negotiations.

⁶ The duration of a license could be affected by acceleration requests due to transfers of ownership or basin-wide management concerns, but this has been, and still is, infrequent.

⁷ Most hydropower dams in the U.S. were built just after WWII, and very few are being built now. There was a small spurt of new hydropower facility construction in the early 1980s after the first oil shock, but by the 1990s new dam construction had again fallen off.

⁸ Procedurally, hold-up problems could come from *any* intervenor in the licensing process wishing to open up and renegotiate the contract, including the dam owner. That is why our theoretical model investigates the factors that affect license flexibility, and not the players.

⁹ Before 1977 FERC was organized as the FPC (the Federal Power Commission). To avoid any impact of this organizational change on the results, the dataset begins with FERC's creation in October 1977.

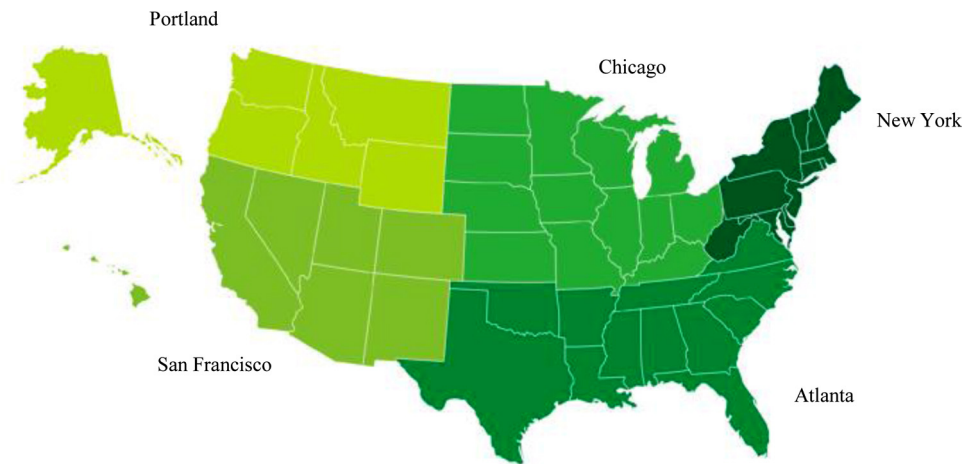


Fig. 2. The five FERC regional offices and their coverage.

number of endangered species (as determined under the federal Endangered Species Act of 1973) listed in the basin of a project in the year in which it applied for a new license.¹⁰ *Government Land* is a dummy variable indicating whether any part of a project is located on government (federal, state, or city) land. Presumably, projects not entirely on private property may undergo greater environmental scrutiny. Finally, *New License* is a dummy variable indicating whether a license is for an entirely new project, as opposed to a relicense for existing hydropower facilities. As mentioned earlier, the majority of licenses (86%) are actually relicenses and few of the observations are for entirely new projects, but it may be the case that those few new projects are held to a higher environmental quality standard, and so this is tested in the empirical analysis.

Also included in the empirical analysis are a few variables that test for a reputation effect on contract completeness. The theory is that stronger reputations and greater trust among contracting parties can lead to more flexible contracts as the parties have less fear of opportunism in the future. *Multiple Owner* is a dummy variable indicating whether the owner of the project seeking a license owns more than one FERC regulated hydroelectric project or not. It indicates a recurring role in repeated licensing processes over time and thus implies that a positive reputation may be relatively more valuable to a repeat player than to a player that only engages in the licensing process once every forty years or so. Approximately 56% of project owners are multiple owners. *Industrial* and *Utility* are indicators for the type of owner of a hydroelectric project (the alternatives being nonutility, municipal, and cooperative). Industrial owners (for example, pulp and paper plants or chemical factories) and utilities, whether justified or not, are often viewed by environmental groups involved in the licensing process as more market-driven and profit-focused than other types of owners, and therefore, potentially less trustworthy. *ALP-ILP* indicates the type of regulatory procedure a license underwent at FERC. There are three licensing procedures available at FERC, the traditional licensing process (TLP) which was used historically by all projects prior to 1998, the alternative licensing process (ALP) which came into use on a voluntary basis after 1998, and the integrated licensing process (ILP), which became the new default licensing process at FERC after

2005. A more detailed description of the background and distinctions between these licensing procedures can be found in Kosnik (2010), but what is important to understand here is that both the ALP and ILP processes are designed to be cooperative and to encourage friendly relations among the involved negotiating parties at an early stage in the licensing process. The ALP and the ILP processes were developed in part *because* the TLP was often seen as contentious and unhelpful in fostering communicative relationships among the negotiating parties. Parties that are involved in an ALP or ILP process, relative to a TLP process, may therefore be viewed as more friendly and trustworthy. Finally, *OI* is a count of the number of official intervenors involved in a project licensing. Anyone can become an official intervenor to a licensing process if they file the paperwork with FERC in a timely manner. Official intervenorship status grants a party the legal right of appeal if they disagree with the final relicensing decision of FERC. Official intervenors tend to be environmental groups with a stake in the licensing outcome and the more of them there are in any particular licensing process, the more contentious that licensing procedure can be expected to be.

Duration is another variable frequently tested with respect to its relationship on contract completeness. As discussed earlier in the background section, the duration of a hydropower license is for the most part restricted to predetermined 50, 40, or 30 year time spans, depending solely on the level of recent capital investments in the project. Although this variable is not therefore determined by the negotiating parties (as traditionally assumed in transaction cost theory), it is included anyway as a test of the theory that the longer a license is expected to last, the greater the degree of flexibility it will embody.

Three decade dummy variables, *1980s*, *1990s*, and *2000s* are included to indicate whether a project was licensed in the 1980s, the 1990s, or the 2000s. These variables account for possible time effects on contract completeness, which could include anything from changing societal preferences affecting license contract provisions, to changing FERC administrators over the decades. The author holds no *a priori* predictions on the signs of these variables in the final regression analyses.

In addition to the HPRA database and the public information gathered on endangered species numbers and wild scenic rivers status, a hard copy of every one of the actual licenses issued by FERC from 1977 to 2007 was also acquired.¹¹ A hydroelectric license is generally structured so that the background information and

¹⁰ This variable was broken down into All Endangered Species and Mammals Only Endangered Species in order to determine if such a distinction made any difference to the results. There is some evidence in the literature that people respond to the fate of (often cute, furry) mammals more than they do to all species in general. In fact, the distinction made no difference to the results so in the empirical section which follows *Endangered Species* refers to the All Endangered Species variable.

¹¹ FERC records indicate that 1343 licenses were issued between 1977 and 2007. The author was able to get copies of 1334 (or more than 99%) of them.

licensing process discussion is at the beginning of the license, and the end of the license contains the mandatory requirements, or “Articles,” a license is subject to in satisfaction of its terms. As mentioned earlier in the background section, whether or not to issue a license at all is rarely up for debate, what is up for discussion between the negotiating parties are the mandatory Articles at the end; what they will contain and how strict they will be. The existence (or not) of a clause in these Articles that specifically allows for future renegotiation of the terms of the Article is called a “Reopener Clause,” and it is an indicator of contract flexibility.

The main dependent variable, *Reopener Clauses*, was created by reading through the environmental Articles at the end of every license, and coding each one as flexible or not depending on whether it contained a Reopener Clause, and then adding up all the Reopener Clauses in a particular license to arrive at a final variable count.¹² A Reopener Clause was always easy to identify. After an Article laid out its terms (be it to require a plan to improve water quality by so many parts per billion, or a requirement to implement ramping rates that would limit water flow variability), an Article either said something to the effect of, “The Commission reserves the right to require changes to the plan,” or it did not.¹³ The language was always straightforward and always clear, and an article either included a Reopener Clause to this effect or it did not. In other words, there was very little subjectivity in identifying and coding these Reopener Clauses. The summary information in Table 1 indicates that the average license had 4.5 Reopener Clauses, but that a license could have as few as zero, or as many as 28 distinct Reopener Clauses.¹⁴

The textual analysis component of the paper is based on the corpus of the complete set of licenses issued by FERC between 1977 and 2007. Digital copies of each of the licenses issued in that timespan were gathered and turned into a text file.¹⁵ The text was then cleaned, for example by removing page numbers, copyright information from the supplying agency (i.e. Westlaw or LexisNexis), and unnecessary addendums and attachments until what remained was the plain license itself.¹⁶ Then individual, unique words were identified in each of the textual documents and entered into a database. This parsing of the text was based on the techniques described in Michel et al. (2011), with only a few deviations.¹⁷ An association was also maintained of the text of each license with metadata about the license itself, such as where the project was located (*Portland, San Francisco, Atlanta, New York, or Chicago*), the year the license was issued, or the size of the project (*kW, Multiple Dams, and Max Dam Height*). This way, it was also possible to

Table 1
Summary statistics.

Variable	Mean	Std. dev.	Min.	Max.
Dependent variables				
Reopener Clauses	4.47	4.60	0	28
Average Length	179.35	77.54	40	1088
MayMust	0.82	0.11	0	1
ShouldShall	0.02	0.02	0	0.18
Independent variables				
kW/10 ³	20.45	108.20	.07	2755.50
Multiple Dams	.17	.38	0	1
Max Dam Height	52.87	77.94	1	773
Plant Type	.70	.46	0	1
Chicago	.18	.38	0	1
Portland	.17	.38	0	1
San Francisco	.17	.37	0	1
Atlanta	.13	.33	0	1
New York	.36	.48	0	1
Wild Scenic	.03	.17	0	1
Endangered Species-All	1.92	2.73	0	31
Endangered Species-Mammals	.58	.96	0	8
Government Land	.39	.49	0	1
New License	.13	.34	0	1
Relicense	.87	.34	0	1
Multiple Owner	.56	.50	0	1
Industrial	.10	.30	0	1
Utility	.25	.43	0	1
Nonutility	.38	.48	0	1
Municipal	.24	.43	0	1
Cooperative	.03	.18	0	1
ALP-ILP	.04	.18	0	1
TLP	.96	.18	0	1
OI	2.66	5.23	0	50
Duration	41.01	7.83	18	50
1970s	.03	.18	0	1
1980s	.57	.50	0	1
1990s	.24	.43	0	1
2000s	.155	.36	0	1

N = 1334.

analyze the license text, limited by particular metadata values. For example, one could generate word frequencies for all the licenses issued to projects in San Francisco, or, for all the licenses that were for projects having a capacity greater than 2000 kW.

An additional dependent variable, *Average Length*, begins the foray into computational linguistics by using the average word length of a license's Articles as a proxy for contract completeness. This variable is created by counting the number of words in each Article in a license and then averaging to come up with the average word length of the particular license's Articles. Table 1 indicates that the average Article length was a bit over 179 words, but that there were Articles as terse as 40 words, and others quite verbose at 1088 words. As stated earlier, the academic literature on textual analysis is slim, so previous evidence is not available to draw on in developing a theory as to whether longer Articles indicate more rigidity, or more flexibility. A reasonable thought argument could be made in either direction – for example, that short Articles are limited, incomplete, and so flexible in interpretation, or, that short Articles are straightforward and to the point and do not allow for flexibility in practice or interpretation. The legal literature appears to be silent on sentence length as related to contractual provision flexibility as well, so we return to the point that it is somewhat difficult to assign a flexibility/rigidity designation to *Average Length* with certainty.

After investigating the Articles in this particular dataset in detail, we make the designation that increasing (decreasing) *Average Length* implies greater flexibility (rigidity). Our results are

¹² Note that *Reopener Clauses* does not include counts of the standard, pro forma articles included in every license on things like annual payments to FERC, terms and conditions affecting interstate or foreign commerce, and the granting of authority to use project lands for common purposes.

¹³ Note that while FERC (i.e. “The Commission”) is the one to procedurally act on a Reopener Clause, as stated earlier in the background section, FERC is but the umpire in this process. They act on a Reopener Clause only if instigated to do so by one of the stakeholders.

¹⁴ A dependent variable was also created, *Percent Reopener Clauses*, which was the percentage of total Articles that contained Reopener Clauses, and the results were not fundamentally different from what is reported in Table 2.

¹⁵ When a license was not available in Word or txt formats (where one can easily use installed word-count features), a license was turned into text using OCR (optical character recognition) software.

¹⁶ While the full license text was maintained, the frequency analyses described below are based only on the text at the end of the licenses, in the Articles sections.

¹⁷ Specifically, this paper deviates in two ways. First, contractions were not included in the corpus. A list of contractions and their unambiguous full forms were identified and converted. Contractions with ambiguous full forms, such as “what’s” were identified and converted by hand using the context of the sentence. Second, the Porter Stemmer was used (Porter, 1980: <http://tartarus.org/martin/PorterStemmer/>) to stem the words, while also retaining their original form in the database.

contextual, therefore, and perhaps less generalizable, but they are at the same time an opening foray into this new area of textual analysis. In sum, after reading tens of thousands of Articles from over a 1000 hydroelectric license contracts, it appears that longer Articles are more flexible. Longer Article provisions tend to be wordier in order to get the greater number of contingencies across as to when the Article applies and in what particular states of the world. Remember that Adaptive Management environmental response techniques rely on iterative decision making to deal with the inherent uncertainty of biological response. In other words, in order to deal with the complexity of environmental systems, sometimes lengthy Articles must be written that employ a lot of detail, but detail that is purposely provided in a flexible manner to respond to evolving, uncertain environmental conditions.

For example, Articles related to water quality can be either short and commanding (“improve water quality by 10 parts per million”), or, they can be longer and open to contingencies (“after three years an improvement in water quality must be demonstrated, as measured in terms of nitrite parts per million, or in terms of oxygen concentrations, or in terms of improved fish mortality rates downstream of the dam”). Similarly, Articles related to water flow rates can be either quite specific and short (“there must be a continuous minimum flow of 75 cubic feet per second”), or they can be long and contingent-laden (“minimum flow should be maintained at an average of 75 cubic feet per second; this can be lower in the dry season from December 1 through March 31, and higher in the rainy season from April 1 through May 15”). In the context under study here, therefore, we make the assumption that wordier Articles are more flexible. Note that the shorter license Articles in this dataset also tend to date from the earlier decades, before Adaptive Management theory took off and a greater understanding developed that there is no certain way to improve various environmental outcomes, and that smart environmental management looked at things flexibly, in a multi-faceted fashion.

There is an alternative interpretation (which the author thanks a reviewer for pointing out) which, for different reasons, in the end also supports the assumption that longer Articles imply greater flexibility. This interpretation is that longer license Articles are written with a good deal of specific, indeed rigid, detail that commands deterministic levels of environmental improvement, but that at the end of these detailed and specific Articles, a reopener provision is inserted to add ultimate flexibility. Evidence for this interpretation would be a high level of correlation between *Average Length* and *Reopener Clauses*, and indeed this is the case ($r = 0.696$). It is not possible with the data available to distinguish between these multiple interpretations of *Average Length*, but in the end they both support the assumption that longer license Articles imply greater flexibility.

The author reiterates that equating longer license Articles with increasing flexibility is an assumption unique to this context (made in part because there is no literature to draw on in this nascent area), and that in other contexts and other textual analyses, it may be that greater sentence length indicates greater contractual rigidity instead.

Frequency analyses of word choice in the licenses are also conducted. Frequency distributions of most texts seem to follow a power law, whereby there is a long tail of words that appear very few times, and a few words that dominate. A frequency analysis on the entire body of text in this context, from all of the licenses put together, as well describes a power law. The most common word in the entire corpus of text is “shall” and it appears 171,634 times. There are nearly 14,000 distinct words in the corpus itself. Frequency distributions on portions of the text, for example text limited by year of license issuance or by project geographic area,

all also exhibit distinct power law distributions.¹⁸ What this tells us is that all inquiries into the text are dominated by key words, and that the majority of the words in any given body of text are actually used rather infrequently. This is helpful with regards to the textual analysis as it allows one to focus on a smaller body of words – the ones that occur with more frequency – in the analysis.

One analytical goal is to look for evidence of flexibility/rigidity changes in particular word choices as a result of uncertainty or asset specific concerns. To this end, word counts of pairs of notably flexible/inflexible words (for example “must” versus “may,” and “shall” versus “should”) are constructed. These counts are then combined into a measure of flexibility that reflects the *proportion* of terms in a given contract that are flexible. Specifically,

$$MayMust = \frac{\sum_i \text{“may”}}{\sum_i (\text{“may”} + \text{“must”})}$$

$$ShouldShall = \frac{\sum_i \text{“should”}}{\sum_i (\text{“should”} + \text{“shall”})}$$

These proportions, measuring between 0 and 1, are then used as dependent variables in an additional set of regressions. The hypothesis is that asset specific concerns in a particular license will decrease these proportional flexibility measures, while usage of more flexible words (such as “may” or “should”), assuming they are related to increased prevalence of uncertainty concerns, will increase these proportionality measures.

6. Regression analysis

The regression analysis is of the form:

$$L_i = f(\rho_i, \mu_i) + \varepsilon_i$$

where L_i is defined (as in the model section above) as the level of contract completeness embodied in a particular hydroelectric license. ρ_i is a vector representing the set of variables indicating asset specificity and reputation effects in a particular licensing process, and μ_i represents the set of variables that indicate uncertainty, as well as duration, in a license. Table 1 presents the summary statistics for the variables used in the regression analysis.

Table 2 presents the OLS regression results for the dependent variables *Reopener Clauses* and *Average Length*.¹⁹ *Reopener Clauses* is the primary dependent variable that measures flexibility in this context, while *Average Length* is the less intuitive dependent variable that assumes flexibility. The results across both dependent variables are remarkably similar. The first, somewhat surprising result, is that the size asset specificity (ρ) variables are for the most part insignificant. *kW*, *Multiple Dams*, and *Plant Type* are all insignificant, across both regressions. Only *Max Dam Height* shows some significance, and that in only one of the regressions. This implies that size asset specificity is not an influential factor in contract completeness, despite the predictions of transaction cost theory. There are two possible reasons for this result.²⁰ One possibility is that while hydroelectric dams are large, capital intensive projects, the ones analyzed in this paper are for the most part over half a century old. The majority of the licenses issued by FERC were, again, for relicenses, not brand new projects. By the time they came

¹⁸ Individual graphs available upon request.

¹⁹ *Reopener Clauses* was run with a poisson regression as well and the results were fundamentally similar. Only OLS results are reported to facilitate comparisons between the two dependent variables, *Reopener Clauses* and *Average Length*. The regressions were also run with the dependent variables as natural logs – to avoid any potential outlier effects – and the results were again fundamentally similar.

²⁰ Both of these reasons were given credence by a lawyer (Matthew A. Love, of Van Ness Feldman) actively involved in FERC hydropower licensing cases.

Table 2
OLS regression results–reopener clauses and average length.

Variable	Reopener clauses		Average length	
	Coefficient	Std. error	Coefficient	Std. error
Constant	−1.80**	0.85	94.39***	13.63
Asset specificity variables (ρ):				
kW/10 ³	−0.00	0.00	−0.02	0.01
Multiple Dams	0.17	0.26	1.90	4.09
Max Dam Height	0.00	0.00	0.11***	0.02
Plant Type	0.16	0.23	−4.32	3.75
Environmental uncertainty variables (μ):				
Wild Scenic	3.75***	0.57	51.72***	9.01
Endangered Species	0.10***	0.04	2.51***	0.58
Government Land	0.45*	0.23	6.20*	3.71
New License	0.12	0.34	−0.98	5.35
Reputation variables:				
Multiple Owner	−0.03	0.21	2.52	3.38
Industrial	−1.16***	0.33	1.13	5.24
Utility	−0.26	0.26	−2.12	4.15
ALP-ILP	−0.18	0.55	−17.06*	8.81
OI	0.25***	0.02	2.73***	0.34
Duration variable:				
Duration	0.07***	0.02	0.73***	0.25
Decade variables:				
1980s	1.54***	0.53	21.82**	8.69
1990s	6.80***	0.56	97.32***	9.05
2000s	5.43***	0.60	112.23***	9.73
Geographic variables:				
Portland	−0.55	0.35	−32.73***	5.67
San Francisco	−2.04***	0.36	−31.90***	5.75
Atlanta	−1.44***	0.35	−15.39***	5.56
New York	−0.94***	0.28	−10.05**	4.45
	Adj. R ² = 0.53		Adj. R ² = 0.54	

* significant at the 10% level.

** significant at the 5% level.

*** significant at the 1% level.

up for relicensing in the dataset the initial capital costs had likely been recouped for these projects and their owners may have felt less concern about threats from potential opportunism on their bottom line.²¹ The second reason is that revenue certainty for (at least utility-based) hydropower owners comes primarily from the ratepayers. Legislation in many states guarantees electric utilities both a consumer base and minimum rates of return. Such legislation works to dampen any potential long-term hold-up concerns on revenues and profits for many hydropower dam owners.

The second interesting finding from the empirical results is that the environmental uncertainty (μ) variables most definitely do matter. The more environmental concern and uncertainty there is with respect to a particular project (as measured by increased presence of endangered species, *Endangered Species*, location of project on a Wild or Scenic River, *Wild Scenic*, or location of a project at least partially on government land, *Government Land*) the greater the flexibility a license contract eventually embodies. This accords with transaction cost theory and *Hypothesis 1* of the model which states that as uncertainty rises, contract completeness should fall (i.e. flexibility should rise). The one μ category variable that does not show any significance, across both regressions, is *New License*. FERC is in fact legislatively mandated to treat relicense applications as equivalent to new license applications (*Yakima Indian Nation*

vs. *The Federal Energy Regulatory Commission*, 746F. 2d. 466), the idea being that a relicense, since it only comes once every 30–50 years, should be treated as a blank slate and approached with a fresh outlook on regulatory and management practices related to the hydropower facilities as well as the river system. It appears from the insignificance of *New License* that FERC is indeed not making any kind of a noticeable distinction between relicenses and new licenses, at least when it comes to the degree of contract completeness the final license issued embodies.²²

The effect of reputation on contract completeness is a little less straightforward. For the most part the reputation variables are insignificant, with *Multiple Owner* and *Utility* showing insignificance across both regressions, and *Industrial* and *ALP-ILP* coming up insignificant in at least one regression each. Only *OI* is significant across both regressions, but it is strongly significant at the 1% level and implies that the degree of contract completeness is affected by the number of intervenors involved in a licensing process. The more official intervenors there are in a process, the more flexible the final license issued ultimately is. As official intervenors are for the most part environmental interest groups, and environmental interests embody uncertainty (*Hypothesis 1*), this makes sense.

The *Duration* coefficient is also strongly significant across both regressions, indicating that as the length of a license increases, so does its flexibility. This conforms with the predictions of transaction cost theory. A number of checks were performed to alleviate any potential multicollinearity concerns between *Duration* and the asset specific variables (ρ). First, the regressions were all run without *Duration* and the primary results still held, including the overall insignificance of the asset specific variables. Second, regressions were run only with observations that involved some capital improvements,²³ and again the primary results held, including the lack of significance of the asset specific variables. Finally, regressions were run only on relicenses (i.e. dropping all brand new projects) and in this instance *kW* becomes slightly significant at the 10% level, but its coefficient is small. The overall conclusion appears to be that *Duration* matters in and of itself (i.e. it is not soaking up significance from the asset specific variables), and that its effect is in the direction predicted by transaction cost theory.

Finally, the decade dummy variables, *1980s*, *1990s*, and *2000s* as well as the geographic region location variables, *Portland*, *San Francisco*, *Atlanta* and *New York*, are all strongly significant across the regressions. The decade variables indicate that contract flexibility steadily increased from the 1970s, through the 1980s, and into the 1990s and 2000s.²⁴ This mirrors society's preferences for environmental activism and protection which has increased from the 1970s through to today (*Madani, 2011*). FERC, therefore, in issuing hydroelectric licenses does appear to be responsive to the period context in which they are issued. The mechanism through which this is achieved is uncertain (be it through the changing of FERC administrations over the years, changing political pressure and oversight from Congress, or something else), but the effect appears strong. The reason for the significance of the geographic location variables is also somewhat unclear, but one hypothesis is that coastal regions (the comparison region in the regressions

²² This indistinction result between new licenses and relicenses does not always hold, however. Evidence presented in *Kosnik (2010)* seems to show a grandfathering effect by FERC in relation to the number and type of environmental regulations mandated per license.

²³ This was done by dropping those observations where *Duration* exactly equaled 30 or 50 (776 observations in total). When *Duration* exactly equals 30 that implies a relicense with no capital improvements, while a license with *Duration* exactly equal to the maximum 50 years is reserved for brand new projects. Any *Duration* value in between can be assumed to be for a project that involved some capital improvements.

²⁴ The same trend is evident using decade dummies or individual year dummies.

²¹ For long term owners of relicenses, in other words, the capital costs may have been viewed as “sunk,” and thus unimportant in forward-looking thinking and decision-making. Geographic asset specificity would still hold, but for some owners at least capital based asset specificity may have been of less importance.

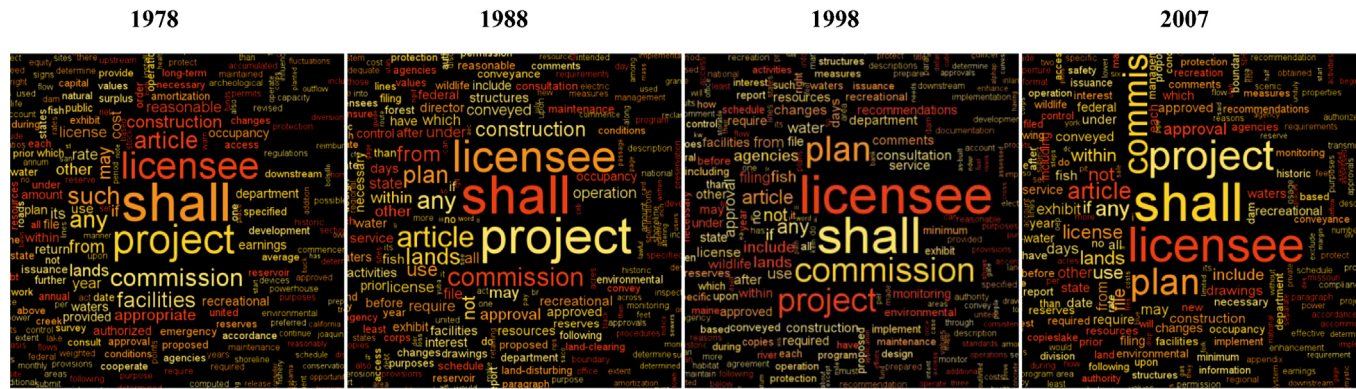


Fig. 3. Word clouds* for 1978, 1988, 1998, 2007.

is Chicago) may end up with less flexible contracts (all of the coefficients are negative) because coastal states prefer less ambiguity when it comes to environmental protection measures. The environmental movement in the U.S. did stem from coastal regions like Portland, San Francisco, and New York, and has generally been less prevalent than in the Midwest regions around Chicago.²⁵

Overall, the result that stands out most clearly from this empirical analysis is that environmental concerns have dominated hydroelectric license contract provisions over the years from 1977 to 2007. Other predictions of transaction cost theory also hold some ground, in the case of duration and reputation effects, but by far the most important factor in influencing contract completeness in this context is environmental concern and uncertainty.²⁶ This effect is further explored in the additional text-based regression analyses.

Table 3 presents the regression results with proportional word counts as dependent variables.²⁷ The hypothesis was that rigid word usage (such as “must” and “shall”) would relatively increase with asset specific concerns while more flexible word choice (such as “may” and “should”) would relatively increase with uncertainty concerns. This does not appear to be the case. Nothing is really significant in these regressions at all. Indeed, it is useful to note that word choice over time, as broadly visualized in word clouds²⁸ (Fig. 3) and in the frequency of the top ten most frequent words (Table 4) does not appear to have changed much over the set of observations in this study.^{29,30} All of this evidence implies that both

Table 3
OLS regression results–MayMust and ShouldShall.

Variable	MayMust		ShouldShall	
	Coefficient	Std. error	Coefficient	Std. error
Constant	0.96	0.02	0.01	0.01
Asset specificity variables (ρ):				
kW/10 ³	0.00	0.00	0.00	0.00
Multiple Dams	0.01*	0.01	–0.00	0.00
Max Dam Height	0.00	0.00	0.00*	0.00
Plant Type	0.00	0.01	–0.00	0.00
Environmental uncertainty variables (μ):				
Wild Scenic	0.00	0.02	0.00	0.00
Endangered Species	–0.00	0.00	0.00	0.00
Government Land	–0.01	0.01	0.01*	0.00
New License	–0.01	0.01	–0.00	0.00
Reputation variables:				
Multiple Owner	0.00	0.01	0.00	0.00
Industrial	–0.00	0.01	–0.00	0.00
Utility	0.01*	0.01	0.00	0.00
ALP–ILP	0.02	0.02	–0.01	0.00
OI	–0.00	0.00	–0.00	0.00
Duration variable:				
Duration	0.00	0.00	0.00*	0.00
Decade variables:				
1980s	–0.13***	0.02	–0.01*	0.00
1990s	–0.22***	0.02	–0.00	0.00
2000s	–0.30***	0.02	–0.01	0.00
Geographic variables:				
Portland	–0.01	0.01	–0.01*	0.00
San Francisco	–0.00	0.01	–0.01**	0.00
Atlanta	0.02**	0.01	–0.01**	0.00
New York	–0.00	0.01	–0.01**	0.00
	Adj. R ² = 0.37		Adj. R ² = 0.08	

* significant at the 10% level.

** significant at the 5% level.

*** significant at the 1% level.

uncertainty and asset specificity concerns appear to have little relevance in distinguishing specific word choices. Simply put, there is not a great deal of change in specific word usage over the body of these licenses.³¹

³¹ While the top seven or eight words appear remarkably consistent over the entire time period under study, there is a drift at the bottom of the table showing that, however slowly, word choice frequency does appear to be changing for words at the end of the top ten frequency distribution (this is related to the concept of “entropy” in the textual analysis literature). This may say more about linguistic trends than

²⁵ Alternative geographic specifications isolating West coast, East coast, midland, and other groupings all show the coastal states having less flexible contracts than the inland states.

²⁶ Note that a number of environmental and asset specificity interactive terms were tested in the regressions, but they were always insignificant and so are not included in any of the final results presented in Tables 2–3.

²⁷ Due to the nature of the dependent variable being a proportion between 0 and 1, four different empirical models were performed: OLS, poisson, glm with a logit link (similar to beta regression), and dependent variable transformation ($\hat{y} = \log[y/(1 - y)]$) with normality assumptions. Every model produced the same insignificance results.

²⁸ A word cloud is a visual representation of word frequency, with the most frequent words appearing in large font in the center of the figure. As words decrease in frequency they are pushed out from the center of the figure and appear in increasingly smaller font. Word clouds allow for quick visualization of relative word importance in a particular body of text.

²⁹ This is true whether broken down by year or, as was also done, by the metadata variables listed in Table 1.

³⁰ In reading many of the licenses in the preparation of this paper, it does become obvious that license Article templates were often used for some of the environmental mandates. This use of templates in the writing of many license Articles may be at least part of the reason for the relatively indistinguishable word type usage over time.

Table 4
Top ten most frequent words.

Top 10 words	All	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07
shall	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
licensee	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
project	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
commission	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
plan	x										x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
article	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
any	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
lands	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x		x	x	x		x	x	x
use	x		x	x	x	x	x	x	x	x				x	x	x	x	x	x				x		x	x	x			x	x
not	x														x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
such		x																													
facilities		x																													
may		x		x																											
from		x	x	x				x	x	x	x	x	x																		
construction			x			x	x	x	x	x	x	x	x	x																	
conveyed					x	x																									
other					x																										
service																															
if																		x													
agencies																			x	x			x				x				
include																					x	x									
approval																								x							
file																															
license																															

Ultimately, what all this indicates is that if flexibility is increasing over time in these license contracts, as the regressions from Table 2 imply, then it is not through subtle, hedging, interpretive word choices in the body of the text of the Articles themselves. Flexibility is more likely incorporated in these contracts through the insertion of straightforward Reopener Clauses, and/or the use of flexibility-embodying Adaptive Management response techniques. Legally, this may be a more defensible approach for inserting flexibility into a contract anyhow.

7. Conclusions

In conclusion, there are three main results from this research. The first is that, by providing a truly direct test of the flexibility/rigidity tradeoff embodied in long term contracts, it offers a robust confirmation of the main predictions of transaction cost theory. The previous literature testing the operationalized factors underlying transaction cost theory (i.e. asset specificity, uncertainty, duration, and probity) relied on indirect or incomplete dependent variables. This paper utilizes a large data set and a dependent variable, *Reopener Clauses* that embodies a comprehensive measure of contract completeness.

Second, this paper offers specific insights on the evolution of U.S. hydroelectric license contracts from 1977 to 2007. In the tradeoff between flexibility and rigidity in these specific long-term contracts, flexibility has won out as the environmental concerns embodying hydropower production have dominated any potential hold-up fears due to asset specificity and the large capital costs of hydroelectric dams. Mirroring broader social preferences from this time period where environmental concerns have grown, the flexibility associated with dealing with environmental concerns have come to dominate hydropower license contract provisions.

Finally, the textual analysis allows us to make some conclusions regarding the form this increase in contractual flexibility has taken. Word choice across the licenses has been relatively consistent over time, implying that the increase in flexibility is not embodied in subtle wording choices such as “must” versus “may” or “shall”

versus “should,” but much more straightforwardly either in the number of well-defined, legally unambiguous reopener provisions utilized, or in the use of detailed Adaptive Management techniques to respond to environmental uncertainty. This is an interesting result. It begs the question of what is the efficient language choice when writing long-term contracts? Note that optimality is not being examined in this paper, only process. Future research investigating optimality, both in language word choice and in levels of contract flexibility or rigidity, would be both an interesting and informative direction to pursue.

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anything, but it would be interesting in the future to extend this table out for many more decades to see if the slow change in some of the top words utilized continues.

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