Transaction Cost Economics and Contract Duration: An Empirical Analysis of EDF Coal Contracts

Stéphane SAUSSIER [(*)]
ADIS – Université de Paris XI Sceaux
ATOM - Université de Paris I Panthéon-Sorbonne

Introduction

In this article we study interfirm contract duration. We focus on a transaction cost economic explanation, suggesting that multiplicity of contractual forms exists and reflects efficiency purposes. The theory's propositions are now well known and have prompted a growing number of empirical studies (Klein and Shelanski [1995]; Crocker-Masten [1996]; Saussier [1997]). These focus on the "make or buy" issue — *i.e.*, the choice of governance structure (Coeurderoy-Quélin [1997]). Few are concerned in the contractual forms of interfirm relationships. Even fewer are based on a sample of contracts suitable for econometric tests of the proposals derived from the theory. We are not aware of any study concerning French data.

This paper aims to measure the theory's usefulness for understanding the diversity of the duration of contractual arrangements between firms. We reassess some of the theoretical propositions and test them econometrically using a contract database. Special emphasis is placed on the testing method: the heuristic model generally tested is replaced by a test of the theory's propositions in their entirety where asset specificity is endogenized. The article is organized as follow. First, we will

---

(*) I am grateful to Eric Brousseau, Scott Masten, Claude Ménard, Oliver Williamson and two anonymous referees, as well as participants at the ATOM, ENSTB, and ADIS seminars where a preliminary draft of this paper was presented. The author has a particular debt towards Jean-Michel Glachant for his indispensable help in the realization of the in-house inquiry necessary to this study. The thoughts expressed in this paper are the author's, not reflecting the views of EDF. Usual caveats apply. The author gratefully acknowledges the financial support of the Scientific Council of the University of Paris I Panthéon-Sorbonne.

look at the reasons for the choice of the duration of contractual relationships. We briefly sum up refutable proposals regarding the duration of the contracts chosen by the parties that can be derived from a transaction-cost framework (Part1). We will then test these proposals on a contract database concerning EDF[(1)] coal unloading and transportation. This database contains *all* the contracts signed between EDF and coal carriers between January 1977 and January 1997. We will describe the relationships between EDF and its partners (Part2) before testing the theory's proposals (Part3). Conclusions follow.

1 The choice of contract duration: some propositions

1.1 A lack of empirical tests

Surprisingly, even if many theoretical approaches coexist, trying to handle the way economic actors coordinate their actions through the contract notion, few of them give clear propositions on the contract form subject. That is especially true for the complete contract theory that emphasis asymmetric information between contracting parties and the incomplete contract theory where non verifiability of relevant contracting variables is crucial (Salanié [1997]). That is not completely true for the transaction cost theory[(2)]. Transaction cost economics propositions gave rise to many empirical studies, and appears sometimes as an "Empirical Success Story" (Williamson [1996]). Nevertheless, empirical studies using a transaction cost economic framework are not very numerous concerning contract duration. Most of them focus on the make or buy problem. In this paper we follow Joskow [1987] and Crocker-Masten [1988] contract duration studies that are the two main empirical studies on the contract duration subject. We believe our paper to be a contribution on the subject because:

1. We are not aware of any study using European data to test the transaction cost theory's propositions concerning contract duration. Such data would permit to confirm results obtained exclusively on American data.
2. We endogenize the level of asset specificity at stake in transactions that allow us to propose very significant test to the theory's propositions.

---

(1) The French State-owned power utility.

(2) For a clear presentation of differences between the incomplete contract theory and the transaction cost theory see Kreps [1996]. For an attempt to put in competition those two theoretical frameworks, see Saussier [1998b].

1.2 Transaction cost economics and contract duration: Some propositions

In a transaction cost economics framework, motivations for long-term contracts are connected with the presence of asset specificity in a transaction. This is related to the fact that, once a specific durable investment is made(3), buyers and sellers are tied up in a lock-in effect due to the cost of canceling the relationship resulting from the non-redeployability of the investments. The quasi-rent generated by the development of specific assets (Klein-Crawford-Alchian [1978]) makes a deal based upon repeated contractual negotiations for the parties unattractive, as the market cannot sanction any deviation. The risk of being a victim of opportunism at contract renegotiation time - each party trying to take the largest part of the quasi-rent - does not encourage the development of specific assets(4). Therefore, when asset specificity is involved in a transaction, it is in the interest of the parties to effect the transaction within a long-term contract. On the other hand, long-term contracts cannot be considered as a complete insurance against opportunistic behavior because of their incompleteness(5). The higher the uncertainty about the transaction, the greater the risks that the terms of the initial agreement chosen by the parties will be unsuitable, implicating high maladaptation costs and possible opportunistic behavior. Transaction-cost economics states that the duration of contracts reflect a desire by the parties to save transaction costs. The duration of a contract can thus be analyzed as an optimization process in which costs and advantages of additional length are traded-off at the margin. The principal gains accruing from the establishment of a long-term contract (as against a shorter contract) are: (1) for the contractant that has developed specific assets, a reduced exposure to the opportunism of the other party; (2) savings on repeated negotiation costs. The principal costs accruing from the establishment of a long-term contract (as against a

(3) There are at least six forms of assets specificity. The non-redeployable character of the investments can be due to their localization (*site specificity*), their physical characteristics (*physical specificity*), the size of the market (*dedicated assets)*, specialized knowledge necessary for the transaction (*human specificity*), their identification to a brand-name (*brand-name specificity*), or the synchronization needed (*temporal specificity*).

(4) This incentive problem is well illustrated by the incomplete contract theory framework (Grossman-Hart [1986]). Nevertheless, in our point of view, this framework misses several important points related to the parties bounded rationality since bounded rationality is not taken into account in this theoretical framework (See Kreps [1996] on this issue).

(5) In a transaction cost framework, any long-term contract is incomplete. The limited rationality of the parties forbids the establishment of a complete contract (Williamson [1985]).

shorter contract) are the information cost, the negotiation cost, and the potential "maladaptation cost" or "renegotiation cost" of being trapped in a bad contract. In order to understand how contracting parties make their choice, we need to identify the factors that influence the costs and the gains of a long-term contract. In keeping within the methodology of transaction-cost economics, we assume that these costs are mainly influenced by transaction characteristics.

a) What factors influence the costs of establishing a long-term contract?

- The greater the uncertainty level of the transaction, the more difficult, expensive, and risky it will be to establish a long-term contract (particularly because of the potential costs of being "trapped" in a bad contract).

Proposition 1 *The costs of a long term contract increase with the transaction-uncertainty level.*

b) What factors influence the gains from a long-term contract?

- A long-term contract will be necessary, especially if the parties have incentives to be opportunistic. Such incentives are directly linked to the presence of specific assets that generate quasi-rent (Klein-Crawford-Alchian [1978]). A long-term contract permits, partly, to save on repeated negotiation costs, that are particularly high when the quasi-rent is significant.

Proposition 2 *The gains of a long term contract increase with the appropriable quasi-rent at stake in the transaction.*

In order to test these two propositions, we have to make an estimate of the following relation:

$$\text{DURATION}_i = \alpha \text{SPE}_i + \beta \text{UNC}_i + \varepsilon_i \,.$$

with

- i : the i^{th} contract,
- DURATION: the contract duration,
- SPE: the level of asset specificity implicated in the transaction,
- UNC: the level of uncertainty around the transaction.

The contract duration appears to be a function positively correlated with the quasi-rent at stake (asset specificity level) and negatively correlated with the transaction-uncertainty level.

2 Contracting in EDF coal procurement: An empirical analysis

To test the choice of contract duration made by economic actors, we had to build our own database. Our sample consists of 70 contracts for the transportation and the unloading of coal to EDF power plants. The selection is exhaustive, as it includes *all* contracts signed by EDF between 1977 and 1997.

We chose to study EDF contracts for several reasons.

1. Électricité de France is one of the biggest French enterprises, with a specialized contracting office. Genuine efforts are made to supply coal to French power plants at the lowest price. While EDF is a public-sector enterprise, it responds to the same incentives and constraints as a private-sector firm. The EDF contracting office, which specializes in coal contracts, is aware that electricity will continue to be produced with coal as long as coal is cheaper than alternative energy sources, especially fuel and gas (Laffont [1996]). That is why the office is constantly seeking to minimize production costs and transaction costs, and why it expressed interest in a study of its contractual choice in regard to transaction-cost proposals. The very survival of the contracting office depends on its ability to cut costs.

2. We focused on transactions between EDF and private-sector partners that transport and unload imported coal, because we assumed such transactions are more likely to be driven by cost minimization. Although EDF uses French coal too, there are no transportation contracts for it: there is only one contract with the French State-owned railroads (SNCF). In this study, we are interested not in these arrangements between EDF and SNCF (for French coal) but in the contracts between EDF and private suppliers that deliver foreign coal to riverside power plants.

3. The degrees of asset specificity and uncertainty are directly relevant to the design of EDF contracts. Some of EDF's suppliers invested in asset specificity; others did not. Also, the coal business changed dramatically during the period studied, causing a heterogeneity in the uncertainty levels tracked by our database. This was one of the reasons why we needed to test the theory's propositions. This heterogeneity of transaction characteristics should be matched by a diversity in contracts.

For all these reasons, we believe our data are particularly well-suited to test the theory's propositions.

2.1 Asset specificity at stake in the relationships between EDF and its suppliers

To test the theory's propositions, we need an accurate measure of two crucial variables: the asset specificity and the uncertainty level involved in each contract. To obtain this information, we carried out a survey at EDF premises. In a series of semi-directed interviews, we questioned EDF personnel in charge of contract negotiation and monitoring. The EDF contracting office also granted us access to many internal documents, which enabled us to distinguish specific investments from non-specific ones.

2.1.1 Physical assets

At some of its power plants, EDF has invested in modern coal-unloading equipment. This allows large time-gains but forces the suppliers to invest in specially shaped coal barges that are compatible only with the EDF unloading system. By contrast, the standard barges used for non-EDF power plants are suitable for transporting coal (for non-EDF customers) or most other types of merchandise. The redeployment of EDF-specific barges would entail costs for several reasons. First, their particular shape is of no use for other potential customers. Second, because of their weight and size, they cannot be easily transported from one river to another. Third, each river has its own characteristics, the most important being depth and sluice size: each river thus requires a specialized type of barge. For all these reasons, we regard the "EDF barges" as specific physical assets that entail the creation of a quasi-rent.

To appreciate the level of physical investments made to meet EDF demand, we used the variable **CAPA**, which measures the transportation capacity in thousands of cubic meters created by a carrier to fulfill an EDF contract. CAPA is equal to zero when the supplier does not deliver coal to a plant equipped with modern unloading equipment, requiring EDF-specific means of transportation.

2.1.2 Site specificity

When the contract concerns a first-time operation at a facility, EDF has to make large-scale investments in the storage area, loading area, and unloading equipment that cannot be transferred to another supplier (there is only one supplier on each river) or elsewhere without very significant cost (this constraint is referred to as site specificity).

To measure the level of site-specific investments attached to the transaction, we could have taken the investments needed to start up the activity considered. These are clearly indicated in contracts. However, as the contracts were not all signed at the same date, we need to deflate the investment amounts. We used the **SITEDEF** indicator, defined as the value of site investments deflated by inflation on the period (1977 = 100).

Since one important effect of the presence of asset specificity to realize a transaction is to create a dependency for the contracting parties over the life of these assets, it seemed interesting for us to define another variable that captures the fact that these assets do not have the same life duration depending of the intensity with which they are used(6). To reflect that, we created the variable **SITECA** defined as site investments needed to realize the transaction concerned by the contract divided by the expected contract turnover in francs.

2.1.3 Dedicated assets

EDF contracts do not mention dedicated assets developed by EDF and its suppliers. Non-specific capabilities developed in response to EDF's demand and which would not find a taker in case of breach of the contract are unknown. We had therefore to use a proxy variable, reflecting the dedicated assets developed. Joskow ([1987], page 172)) states that the notion of dedicated asset implies that the importance of this factor in the determination of the contract duration varies with the contractualized quantities, in all respects. The higher the annual quantities involved, the more difficulty the supplier will have to redeploy his assets to other customers. It is a very indirect measure, but we have no better one at hand.

Unfortunately, there were few contracts that specify a precise quantity to be supplied. Some of them specify the minimum quantities EDF will take over the period. Others specify the minimum quantities the supplier must be able to assure over the contract period. These two quantities are pertinent to reflect dedicated assets involved in the transaction.

Consequently we created the variables QGUAREDF (quantities guaranteed by EDF) and QGUARSUP (quantities guaranteed by suppliers) corresponding to the contractualized monthly quantities in thousands tons, to appreciate dedicated assets involved in the transactions. We defined the Variable QUANTITY like the average of these two variables(7).

(6) It is not so with physical assets because whatever the intensity with which barges are used, their life duration is about twenty years.

(7) It appears that results are not change if we choose QGUAREDF or QGUARSUP instead of Variable **QUANTITY**. Estimations are available on request.

2.1.4 Human assets

We cannot arrive at a precise measure of human asset *i.e.*, knowledge developed for a contract and that cannot be redeployed for another use or another client. Such assets may exist, especially because the capacity to conduct barge on certain rivers is very difficult to obtain (length of specialized training) and is of little redeployability when EDF is the transporter's principal customer. However, we know that such assets probably increased after 1992. The use of coal has fallen off sharply since 1992, causing a business downturn for EDF carriers (figure 1). This poses a major problem for EDF[8], which has to decide whether to drop some of its suppliers or to support them in order to respond effectively to a possible future increase in coal use. In earlier days, the carriers' experience could not be regarded as a specific human asset. Today, with EDF accounting for so great a share of the carriers' business, this type of asset is increasingly specific[9].

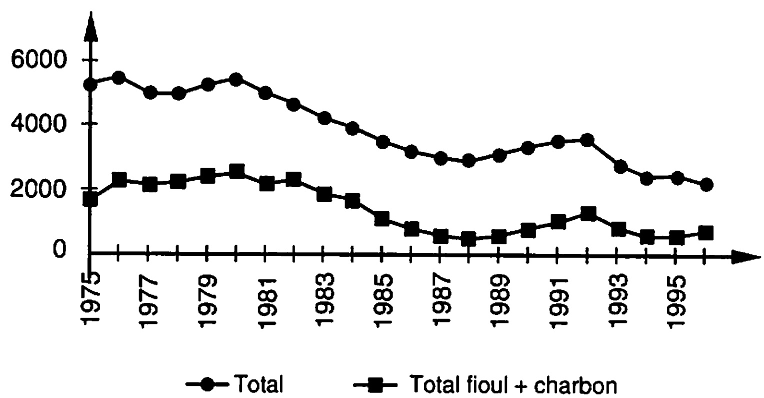

Figure 1
Total volume transported on all French rivers, in millions of metric tons per kilometer (Source: Voies navigables de France 1997)

To reflect this change we created a dummy variable, DUMMY92, whose value equals unity for contracts signed after 1992.

---

[8] As shown in figure 1, coal transportation slumped in 1987-88, but the situation was not so problematic for EDF at this time because the overall level of transportation activity on French rivers was higher than in 1992-97.

[9] The contraction in EDF business coincided with a decline in the total river transportation business. As a result, despite its decline, EDF procurement now represents a great share of the transportation providers' total business that can not outlive without it.

Our interviews at the EDF contracting office did not reveal any temporal specificity or brand-name capital, which are the last asset-specificity categories identified by the theory.

We did not identify any asset specificity involved in road contracts: these are signed during crises when the system is under tension and near breaking-point. In such situations, EDF has to provide coal to its plants, and is ready to do so at any price. Concerning relationships between EDF and its unloading suppliers, it seems to have no asset specificity at stake. The unloading activity is just concern by finding dockers to do the job. All the physical assets needed for this operation are not owned by the unloading company but by the French ports.

2.2 Uncertainty level at stake in the relationships between EDF and its suppliers

The contract database used for our study is valuable because of the heterogeneity of the asset specificity involved in the transactions. The period studied (1977-97) is also of particular interest because of the changes in the exogenous disturbances affecting the transactions. This period can be split into three distinct sub-periods:

- 1977-79: increase in EDF demand, with a rise in quantities transported to and unloaded at EDF plants. There is some uncertainty as to the quantities, but the resulting disturbances were neither frequent nor serious.
- 1980-86: downturn in EDF demand, with a *planned* cutback in transported and unloaded volumes. This contraction was due to the growth of nuclear power. Disturbances were greater and more frequent than before, but never very substantial.
- 1987-97: *unplanned fluctuations* in EDF demand, resulting in highly variable and hard-to-predict transported and unloaded volumes. Because of the growth in nuclear power (figure 2), coal was viewed only as a back-up source in the event of capacity tensions in the system's "hard core".

The fluctuations were mainly due to shocks in the French nuclear program (figure 3). The shocks were *unpredictable* and coal was used to fill temporary shortfalls.

We can therefore expect a difference between the 1977-79 and 1980-97 sub-periods in the transaction uncertainty regarding the quantities of coal to be supplied to EDF. The uncertainty increased in the 1980-97 sub-period because the exogenous disturbances were larger and more frequent than in 1977-79. To take this change into account, we created

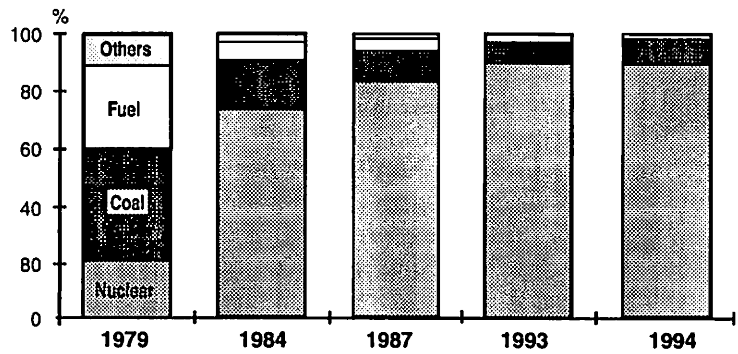

Figure 2
Annual energy production by fuel (Source: EDF Production-Transport: Résultats techniques d'exploitation (January 1995)).

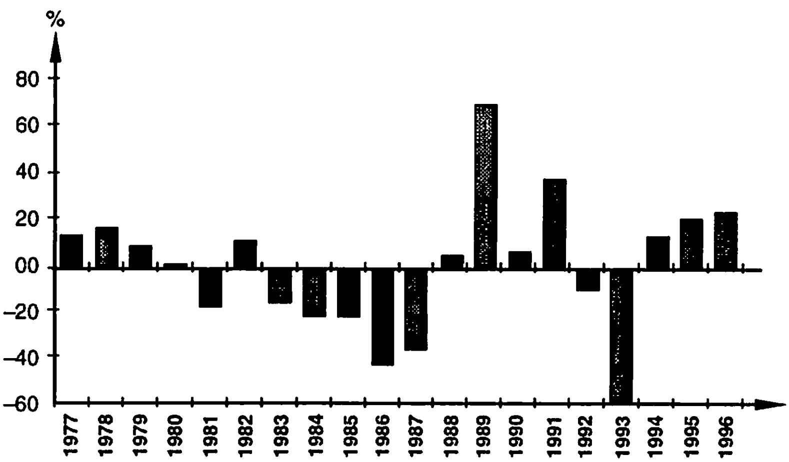

Figure 3
(%) Annual changes in coal consumption (Source: EDF Contracting Office (January 1997)).

two dichotomous variables, **DUMMY80** and **DUMMY87**, with respective unit values for contracts signed in 1980-86 (DUMMY80) or 1987-97 (DUMMY87). The purpose of the dummies was to measure the changes in the chosen contract duration of EDF contracts due to the exogenous disturbances.

We did not identify other possible sources of uncertainty. Previous empirical studies showed that uncertainty is sometimes due to transaction complexity, but this is not the case here. Coal transportation is a transaction easy to define. The period is characterized the same way for coal transportation and coal unloading activities.

3 Empirical results

3.1 Expected results

The variables we created allow us to test the theory's propositions concerning the contract duration of EDF contracts.

Table 1: Description of the Variables*

Used variables	Definition	Obs.	Mean	Std. Dev	Min	Max
DURATION	Duration of the contract signed, in months	29	30.65	35.9	1	120
SITECA	Site investment in millions of francs divided by the expected contract turnover.	29	1.19	2.98	0	11.2
SITEDEF	Site investment in millions of francs divided by inflation index (1977 = 100)	29	2.22	7.54	0	39.8
QUANTITY	(Month quantities guaranteed by EDF + month quantities guaranteed by the supplier)/2 (in thousands of tons)	29	38.2	47.2	0	199.5
CAPA	Transportation capacity, in thousands of cubic meters, created to satisfy EDF demand if on an EDF-specific route, 0 otherwise.	29	2.01	6.17	0	30
DUMMY 92	Dichotomic variable equal to unity if contract signed between 1992 and 1997, 0 otherwise.	29	0.27	0.45	0	1
DUMMY 87	Dichotomic variable equal to unity if contract signed between 1987 and 1997, 0 otherwise.	29	0.82	0.37	0	1
DUMMY 80	Dichotomic variable equal to unity if contract signed between 1980 and 1986, 0 otherwise.	29	0.10	0.30	0	1
ROAD	Dichotomic variable equal to unity for road contract, 0 for river contract	29	0.20	0.41	0	1

* We are focusing our econometric test on transport contracts because of their heterogeneity. That is why we have only 29 observations in table 1 and no UNLOAD variable.

Variables CAPA, SITEDEF/SITECA, QUANTITY and DUMMY92 were used to reflect the level of asset specificity at stake, which is directly linked to the level of the quasi-rent generated in the transaction. These variables were expected to have a positive effect on contract duration.

For the transaction uncertainty level, we use DUMMY87 and DUMMY80. We therefore expect DUMMY87 and DUMMY80 to reduce contract duration, with a greater effect for DUMMY87.

To measure the differences between road contracts and river contracts, we created the **ROAD** variable. To measure the differences between unload contracts and river contracts, we created the **UNLOAD** variable.

3.2 Estimation results

Table 2: Contract duration estimates (t-ratios in parentheses)

	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Independent Variables	DURATION (1)	DURATION (2)	DURATION (3)	DURATION (4)	DURATION (5)	DURATION (6)	DURATION (7)	DURATION (8)
CAPA	2.22 (6.11)***	2.17 (9.57)***	2.13 (9.56)***	2.37 (9.80)***	1.71 (4.14)***	1.85 (5.76)***	1.85 (5.73)***	2.24 (7.39)***
SITECA	4.58 (5.30)***	3.74 (6.83)***	3.70 (6.73)***	4.33 (7.54)***				
SITEDEF					1.74 (4.32)***	1.32 (3.89)***	1.30 (3.78)***	1.24 (4.32)***
QUANTITY	0.28 (4.77)***	0.23 (6.35)***	0.24 (6.42)***	0.21 (6.94)***	0.28 (4.25)***	0.25 (5.05)***	0.26 (5.06)***	0.25 (6.64)***
DUMMY92	14.61 (2.69)***	24.01 (6.53)***	25 (6.55)***	15.18 (6.22)***	25.39 (3.67)***	30.91 (5.81)***	31.88 (5.78)***	17.64 (5.77)***
DUMMY80		−12.15 (−2.01)*	−12.16 (−2.01)*	−15.58 (−2.59)**		−16.09 (−1.90)*	−16.02 (−1.87)*	−16.02 (−2.19)**
DUMMY87		−30.98 (−6.03)***	−32.11 (−6.09)***	−27.20 (−4.77)**		−30.98 (−4.47)***	−32.62 (−4.49)***	−27.94 (−4.49)***
ROAD			3.34 (0.97)	−0.97 (−0.26)			3.68 (0.78)	−1.90 (−0.42)
UNLOAD				−1.61 (−0.31)				−4.74 (−0.77)
CONST	5.80 (2.17)**	33.11 (6.65)***	32.90 (6.59)***	32.43 (5.86)***	5.11 (1.74)*	33.17 (4.88)***	32.96 (4.81)***	33.92 (5.04)***
Adj. R-squared	0.90	0.96	0.96	0.91	0.88	0.93	0.93	0.86
Observations	29	29	29	70	29	29	29	70

*** denotes significance at 1% level; **denotes significance at 5% level; * denotes significance at 10% level

Transaction cost economics propositions are largely confirmed, whatever Variable we choose to reflect site specificity (SITEDEF or SITECA) involved by the contract. The various types of asset specificity involved in the relationship between EDF and its suppliers have a significant influence upon the contract duration chosen. The first estimate of EDF contract duration (DURATION(1), DURATION(5)) confirms the importance of asset specificity in the determination of contracts duration. The constant term appreciate the duration of a transport coal contract signed without any specific asset involved in the transaction.

The effect of DUMMY87 and DUMMY80 (DURATION(2), DURATION(6)) are negative with DUMMY87 having a larger effect as expected. The constant term appreciate the duration of a transport coal contract signed before 1980 without any specific investment. The results suggest contracts which do not involved assets specificity are longer when the period does not present uncertainty.

Results are not significantly changed if we consider the entire data base of contracts, controlling for differences between transactions with UNLOAD and ROAD dummy variables (DURATION(4), DURATION(8)). Including all unload contracts without any asset specificity involved (70 contracts sample) does not change results showing that EDF transport contracts without any asset specificity involved are of no longer duration than EDF unload contract duration without any asset specificity involved.

We are not able to make an econometric test concerning unload contracts duration. Like we have seen, this transaction does not involve any specific asset. Even if we have different levels of uncertainty around this transaction, it is not surprising to see that the contracts are identical. They are all one year contracts. Uncertainty seems to be a real contractual problem only in conjunction with asset specificity. Nevertheless, we can note that the EDF unload contract duration changed after June 1992, after a French law was adopted concerning the employment rules concerning dockers(10). There were only three contracts signed after June 1992 by EDF. All of them were two or three years duration contracts. Moreover, they were more precise contracts, with minimal quantities and penalties for EDF. That seems to be consistent with the idea that the new regulation changed unload company flexibility and more precisely, changed transaction characteristics, to induce more dedicated assets. Nevertheless, it is too early to be more precise on this question.

Transaction-cost economics propositions are thus confirmed. Nevertheless, while our results confirm the theory, we should note that asset-specificity variables may be endogenous, and *should be endogenized* (Williamson [1993]; Masten [1995]).

(10) This French law was adopted in order to oblige unloading companies to employ dockers like regular workers that is to say through labour contracts that specify a month-rate payment and not an hour-payment like it was the case before. After this law, dockers can not be paid for a day or a semi-day of works. They take part of the unloading company and may become what could be called dedicated assets in case of decreasing of the market.

3.3 Asset-specificity endogeneity

The second step in testing the theory's propositions should be to find variables reflecting the decision to make specific investments. Many empirical studies that attempt to refute transaction-cost economics ignore the possible endogeneity of asset specificity when testing the heuristic transaction-cost model (Compare Williamson [1985], chapter 4 and Riordan-Williamson [1985]) or avoid the endogeneity problem by estimating a reduced-form using proxies to reflect asset specificity levels at stake in transactions (Masten-Saussier [1998]). These approaches—e.g. the one used for the table 2 estimates, which ignores asset specificity endogeneity—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 asset specificity at stake in transactions. Williamson's advice 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" (Williamson [1993], p. 27).

This point requires urgent attention in the development of empirical tests for the theory:

> "The specificity of assets and the level of investment in those assets that determine the size of appropriable quasi-rents are themselves decision variables. The location of facilities, the adoption of specialized designs or equipment, and the scale of investments should all, by rights, be treated as endogenous variables" (Masten [1995], page 60).

To endogenize CAPA, SITEDEF, SITECA and QUANTITY, we identified several elements that could influence the willingness of the parties to invest in specific assets:

1. The river concerned by the contract (Loire, Seine or Rhône): each river has its distinct characteristics (depth, distance between port and power plants, sluice size) that influence technical choices and investment levels.

   We expect a greater asset specificity in contracts for coal transportation on the Loire, since the river's sluices are larger than those on the Seine and the Rhône, and the distance between the port and power plants is shorter. These are two good reasons for EDF and its suppliers to make more specific investments than on other routes in order to cut transportation costs. We therefore introduced two dichotomic variables: **LOIRE**, equal to unity for contracts to transport coal on the Loire, and SEINE, equal to unity for contracts to transport coal on the Seine[11].

2. The changes in coal consumption by the French power-generation industry: with the decline in the use of coal to produce electricity, the incentive to develop asset specificity (in order to reduce production costs) may disappear. To take this into account we introduced the variable **DELTCONS**, which is the annual residual demand for coal in gigawatts per hour after nuclear production. This residual demand was strong until 1987, but has since fallen sharply.

3. The electrical output of the power plant concerned by the contract: each contract applies to a different plant, each with a different output. There are eleven coal-fired power plants in France, whose outputs range from 250 MW to 1800 MW[12]. To take into consideration this size effect, we introduced the variable **DELTPUISS**, which is equal to the output of the plant concerned by the contract multiplied by the residual demand for coal. This enables us to distinguish between the overall effect of the decrease in coal consumption (DELTCONS) and the effect of this decrease on each power-plant unit (DELTPUISS).

Used variables to endogenize asset specificity levels at stake in transactions, and their explanatory power are shown in tables 3 and 4.

Table 3: Used variables to endogenize asset specificity levels

Used variables	Definition	Obs.	Mean	Std. Dev	Min	Max
LOIRE	Dichotomic variable equal to unity if contract signed is concerning Loire river.	29	0.06	0.25	0	1
SEINE	Dichotomic variable equal to unity if contract signed is concerning Seine river	29	0.41	0.50	0	1
DELTCONS	The annual residual demand for coal in gigawatts per hour after nuclear production is taken into account ($/10^3$)	29	72.8	45.9	34.9	190.7
DELTPUISS	The output of the plant concerned by the contract multiplied by the residual demand for coal($/10^7$)	29	6.60	7.08	1.54	28.6

We perform new estimates for DURATION using 2SLS. Results are presented in Table 5.

(11) The Rhône variable is not put in the regression because of colinearity problems. Coefficients concerning Loire and Seine are thus estimated relatively to what is chosen if the contract concerns the Rhône river.

(12) The output for each plant, however, did not vary during the period under review. We therefore consider it as an exogenous variable, as it was chosen well beforehand by EDF.

Table 4
Instrumental variables estimation (LOIRE, SEINE, ROAD, DELTCONS, DELTPUISS, DUMMY92, DUMMY87, DUMMY80)

Dependent Variables	Obs.	R^2	Significant Variables			
CAPA	29	0.42	DELTPUISS** (+)			
SITEDEF	29	0.81	LOIRE***, (+)	DELPUISS**, (+)	DELTCONS** (+)	
SITECA	29	0.70	LOIRE***, (+)	DELTCONS**, (+)	DUMMY92* (+)	
QUANTITY	29	0.77	LOIRE***, (+)	DUMMY92**, (+)	SEINE**, (+)	DELTCONS** (+)

*** denotes significance at 1% level; **denotes significance at 5% level.

Table 5: Contract duration estimates (t-ratios in parentheses)[a]

	2SLS**	2SLS*	2SLS	2SLS**	2SLS*	2SLS*
Independant Variables	DURATION (9)	DURATION (10)	DURATION (11)	DURATION (12)	DURATION (13)	DURATION (14)
CAPA	2.15 (9.27)***	2.13 (9.25)***	2.66 (4.33)***	1.93 (5.67)***	1.80 (4.62)***	1.27 (1.70)*
SITECA	3.37 (5.53)***	3.98 (3.14)***	4.91 (2.67)**			
SITEDEF				1.05 (2.74)***	1.45 (1.94)*	1.60 (1.92)*
QUANTITY	0.29 (5.97)***	0.25 (3.15)***	0.16 (1.30)	0.33 (5.01)***	0.28 (2.53)**	0.29 (2.39)**
DUMMY92	23.07 (5.39)***	23.90 (5.61)***	23.25 (4.35)***	27.69 (4.47)***	31.10 (3.85)***	33.66 (3.60)***
DUMMY80	−12.22 (−1.93)*	−12.67 (−2.03)*	−15.13 (−1.86)*	−15.18 (−1.72)*	−17.30 (−1.85)*	−16.67 (−1.57)
DUMMY87	−31.37 (−5.71)***	−30.99 (−5.71)***	−31.34 (−4.65)***	−31.70 (−4.16)***	−30.97 (−4.14)***	−29.75 (−3.60)***
ROAD	4.01 (1.12)	3.49 (0.96)	2.29 (0.49)	4.73 (0.95)	3.92 (0.78)	4.04 (0.74)
CONST	31.31 (5.96)***	31.58 (6.09)***	33.54 (4.98)***	30.64 (4.21)***	30.98 (4.37)***	29.60 (3.75)***
Adj. R-squared	–	–	–	–	–	–
Observations	29	29	29	29	29	29

2SLS* when CAPA is supposed exogenous; 2SLS** when CAPA and SITEDEF or SITECA are supposed exogenous. *** denotes significance at 1% level; **denotes significance at 5% level; * denotes significance at 10% level. [a] We focused on the 29 sub-sample because the instruments we chose are not available for unload contracts.

These results, also, corroborate the theory's propositions (table 5), although they display differences with the previous OLS estimates (DURATION(11) and DURATION(14) versus DURATION(3) and DURATION(7)). It is probably because our instruments do not reflect well the willingness of the parties to invest in physical assets. As soon as we consider CAPA as an exogenous variable (DURATION(10) and DURATION(13)) or CAPA and SITEDEF/SITECA as exogenous (DURATION(9) and DURATION(12)), whatever the specification choice that is made (SITECA or SITEDEF to reflect site specificity level), all coefficients display the predicted sign and are not far from estimates where endogeneity bias is not corrected.

Conclusion

In this paper we dealt with the choice of contract duration in interfirms agreements. In order to test the proposals derived from transaction cost theory concerning duration of inter-firm contracts, we built a database of contracts. This allowed econometric testing of these proposals. Because we used these contracts but also outside information about them, we assessed in details the specificity of assets involved, thus avoiding as far as possible measurement errors. Furthermore, our sample was not censored as in the majority of those used in previous studies (Joskow [1987]; Crocker-Masten [1988]).

Our study set out to emphasize that transaction-cost economics allows refutable propositions concerning contractual duration. The key results are (1) to confirm those propositions using, we believe for the first time, a European contract database and (2) to refine usual tests, to permit testing the theory's propositions more significantly by collecting more precise data that allowed us to endogenize asset specificity involved in each transaction.

REFERENCES

COEURDEROY, R. and B. QUÉLIN [1997], L'économie des coûts de transaction. Un bilan des études empiriques sur l'intégration verticale, *Revue d'Economie Politique*, **107**(2), pp. 145–181.

CROCKER, K.J. and S.E. MASTEN [1988], Mitigating Contractual Hazard: Unilateral Options and Contract Length, *Rand Journal of Economics*, **19**(3), pp. 327–343.

CROCKER, K.J. and S.E. MASTEN [1996], Regulation and Administered Contracts Revisited: Lessons from Transaction-Cost Economics for Public Utility Regulation, *Journal of Regulatory Economics*, **9**(1), pp. 5–39.

GROSSMAN, S.J. and O.D. HART [1986], The Costs and Benefits of Ownership: A Theory of Vertical Integration, *Journal of Political Economy*, **94**(4), pp. 69-719.

JOSKOW, P.L. [1987], Contract Duration and Relationship-Specific Investment: Empirical Evidence from Coal Markets, *American Economic Review*, **77**(1), pp. 168–185.

KLEIN, B.V., R.G. CRAWFORD and A. ALCHIAN [1978], Vertical integration appropriable quasi-rents and the competitive contracting process, *Journal of Law and Economics*, **21**(2), pp. 297-326.

KLEIN, P. and H. SHELANSKI [1995], Empirical Research in Transaction Cost Economics: a Survey and Assessment, *Journal of Law, Economic and Organization*, **11**(2), pp. 335-362.

KREPS, D.M. [1996], Markets and Hierarchies and (Mathematical) Economic Theory, Mimeo.

LAFFONT, J.J. [1996], The French Electricity Industry, in Gilbert R. J. and E.P. Kahn (Eds), *International Comparisons of Electricity Regulation*, Cambridge, Cambridge University Press.

MASTEN, S.E. [1995], Empirical Research in Transaction-Cost Economics: Challenges, Progress, Directions, *in* J. Groenewegen (Ed.), *Transaction Cost Economics and Beyond*, Amsterdam, Kluwer Academic Press, pp. 43–64.

MASTEN, S.E. [1998], Nominal Terms, Real Intentions, and Contract Interpretation, 2nd international conference on New Institutional Economics, Paris, September.

MASTEN, S.E. and S. SAUSSIER [1998], Econométrie des contrats: un bilan des développements récents de la théorie des coûts de transaction, XLVII[e] congrès annuel de l'Association Française de Sciences Economiques (AFSE), Paris, Septembre.

RIORDAN, M.H. and O.E. WILLIAMSON [1985], Asset Specificity and Economic Organization, *International Journal of Industrial Organization*, **3**(3), pp. 365-378.

SALANIÉ, B. [1997], *Contract Theory: A Primer*, Cambridge, MIT Press.

SAUSSIER, S. [1997], *Choix contractuels et coûts de transaction*, thèse de doctorat, Université ParisI, Panthéon-Sorbonne.

SAUSSIER, S. [1998a], Contractual Incompleteness and Transaction Costs: An Econometrical Test, Working Paper ATOM, Université Paris I, Panthéon-Sorbonne.

SAUSSIER, S. [1998b], When Incomplete Contract Theory Meets Transaction Cost Economics, Working Paper ATOM, 2nd international conference on New Institutional Economics, Paris, September.

WILLIAMSON, O.E. [1985], *The Economic Institutions of Capitalism*, New-York, Free Press.

WILLIAMSON, O.E. [1991], Comparative Economic Organization: The Analysis of Discrete Structure alternatives, *Administrative Science Quarterly*, **36**(2), pp. 269-296.

WILLIAMSON, O.E. [1993], The Economic Analysis of Institutions and Organisations - In General and With Respect to Country Studies, Working Paper n- 133, OCDE.

WILLIAMSON, O.E. [1996], *The Mechanisms of Governance*, Oxford. Oxford University Press.