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Transaction costs and contractual incompleteness: the case of Électricité de France

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Abstract

This paper explores the incompleteness of inter-firm contracts through the lens of recent developments in transaction cost economics. We built a non-truncated contract database representing all the relationships of Électricité de France (EDF) with its coal-carriers over the period 1977–1997. We tested and corroborated most propositions derived from transaction cost theory relating contractual incompleteness to transaction characteristics, even when we considered the complete set of the theory's propositions by endogeneizing the asset specificity at stake in transactions. To our knowledge, this kind of test has never been conducted before.

JEL classification: L14; L92; L94

Keywords: Contract theory; Contract design; Transaction cost

1. Introduction

Why do observed contracts so often leave contracting parties' obligations vague or unspecified? In this article, we argue that this incompleteness is often the result of contracting parties willingness to minimize costs. The level of incompleteness is then analyzed as an endogenous choice that should not always be viewed as a badly designed contract. We explore this question, using the framework of the transaction cost theory, as principally expounded by Williamson (1975, 1985, 1996).

The theory's propositions are now well known and have prompted a growing number of empirical studies as surveyed by Klein and Shelanski (1995) and Crocker and Masten (1996). However, they usually focus on the 'make or buy' decision, i.e. the choice of governance structure. Few concern the contractual forms of inter-firm relationships. Even fewer are

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based on sample contracts suitable for econometric testing of the proposals derived from the theory.

The purpose of this paper is to measure the theory's usefulness in understanding the diversity of contractual arrangements between firms. We reassess some of the theoretical propositions and test them econometrically using a French contract database. Special emphasis is placed on the testing method. We argue that the heuristic model generally tested needs to be replaced by fuller tests of the theory's propositions in their entirety. We propose such a test.

We believe our paper to be a contribution on the topic. First, we are unaware of any study using European data to test the transaction cost theory's propositions regarding contractual incompleteness. Such data would permit confirmation of the results obtained exclusively from American Data. Second, according to the Williamson (1993) and Masten (1995) advisory, we endogenize the level of asset specificity at stake in transactions. This allows us to propose a very significant test of the theory's propositions. To our knowledge, this kind of test has never been conducted before.

The paper is organized as follows. First, we will look at the reasons for the choice of contractual incompleteness and refutable proposals (Section 2). We proceed to test the latter on a contract database with regard to the coal transportation sector. This database contains all the contracts signed between the French State-owned power utility (EDF) and coal carriers from January 1977 to January 1997. We then describe the relationships between EDF and its coal carriers (Section 3) before testing the theory's proposals (Section 4).

2. Contractual incompleteness: some propositions

When economic agents decide to collaborate, they usually create a 'contract interface' to guide the transaction, the subject of the collaboration. To maximize the gains the interface must be correctly designed. In real life, many types of contracts exist. Some are very precise, and strive for completeness; others are very 'light-weight' and are obviously incomplete. How can we explain these differences? What motivates contractual choices by economic agents? To address these questions, we must first understand why people sign incomplete contracts.

2.1. On the use of incomplete contracts

Economic literature usually distinguishes two types of complete contracts: contingent-claims contracts and comprehensive contracts.

Contingent-claims contracts are contingent on all the variables relevant to contract fulfilment. Typical examples are in the Arrow-Debreu model contracts based on rationality and symmetric information assumptions. All states of nature are observable and verifiable, so there is no possibility for adverse selection or moral hazard.

In the presence of private information, complete contingent-claims contracts are no longer feasible. Complete (or comprehensive) contracts can nevertheless be made, provided they take into account all the relevant information and are contingent on verifiable variables: this makes it possible to specify each party's obligations in every conceivable eventuality (Hart, 1987; Holmstrom and Tirole, 1989).

Measured against the complete-contract benchmark, an incomplete contract is, therefore, one that does not take into account all the relevant variables. But why would economic agents sign such contracts? Proposed explanations usually relate to the bounded rationality of economic agents and the verifiability of variables pertaining to contract fulfilment (Schwartz, 1992; Salanié, 1997) [1] .

Since bounded rationality is hard to formalize, it is easy to view the incompleteness of contracts as being due only to the non-verifiability of many variables. Economic agents should be able to foresee all contingencies that might affect the contract and be able to decide what they should do. But they are unable to make a clear and enforceable contract because of the inability to verify the relevant variables. This is the approach used in the theory of incomplete contracts, which speaks alternatively of contractual incompleteness or non-verifiability. [2] The models developed in this theoretical framework yield some interesting results, especially concerning the effects of incompleteness on *ex ante* investment incentives. This is well illustrated by Grossman and Hart (1986). Nevertheless, these models generally assume information symmetry between contracting parties an assumption that is not entirely satisfactory as pointed out by Salanié (1997), Tirole (1994) and Masten (1999). Furthermore, contractual incompleteness is due only to external constraints (See Kreps, (1996) in this issue). In such a contract as in complete contracts no previously unexpected contingency can arise to disrupt the contract's fulfilment. Bounded rationality is excluded from the analysis (Hart, 1990). Finally, in this theoretical framework, incompleteness is postulated rather than actually explained as suggested by Williamson (1996, p. 12, fn. 7). The incomplete contract theory sheds some light on the impact of contractual incompleteness, but is of no help in understanding differences in contractual completeness levels nor does it measure the extent to which those levels result from the parties' goodwill. Contractual incompleteness is exogenous and does not result from a trade-off made by economic actors. As Hart (1995, p. 134) pointed out, an incomplete contract is analysed as one where 'the parties would like to add contingent clauses, but are prevented from doing so by the fact that the state of nature cannot be verified (or because states are too expensive to describe ex ante'). Generally, this theoretical framework predicts an all or nothing solution: the contract is complete or totally incomplete (i.e. no contract is signed). [3]

In what follows, we take a transaction cost economics approach, taking into account the bounded rationality that might affect the choice of the contractual-incompleteness level. [4] We do not consider contractual incompleteness as exogenous, we see it as the result of the parties' willingness to save transaction costs. This theoretical framework does not yet allow a complete formalization of the problem. Nevertheless, testable propositions can be derived from it.

[1] See Bernheim and Whinston (1998) for an interesting alternative explanation, based on the idea that parties often fail to specify verifiable obligations of the parties because once some aspects of performance are unverifiable, it may be optimal to leave other verifiable aspects of performance unspecified.

[2] See Hart and Moore (1999) and Maskin and Tirole (1999) on this issue. The observable but non-verifiable assumption is enough to justify a high degree of contractual incompleteness provided that the parties cannot commit not to renegotiate.

[3] See Hart and Moore (1999) for an attempt to develop a theory of 'partial' incompleteness.

[4] See Saussier (2000) for an attempt to put in competition the views of transaction cost theory and incomplete contract theory.

2.2. Saving transaction costs

In the transaction cost economics approach, the complete-contract benchmark is unattainable. The vital question is not incompleteness in itself, but rather 'the reasons for which some contracts are more incomplete than others' (Al-Najjar, 1995). Contracting parties are supposed to be unable to take into account all contingencies that might affect a transaction. Moreover, they do not always know the optimal response to foreseeable contingencies that should be stated in the contract. The completeness level is, therefore, difficult to evaluate. Every provision in a contract is assumed to be imperfect, and specifying a particular provision may be worse than specifying nothing. Hence, when we talk about a 'more complete' contract in this paradigm, we refer to one that tends to specify every dimension of the transaction, but does not necessarily use all the relevant information. That is the definition of 'feasible' completeness adopted in this article: *one contract is more complete than another if it gives a more precise definition of the transaction and of the means to carry it out*. This approach maintains a reachable upper bound. Under our definition, a contract that specifies how to perform the transaction in every conceivable case is a complete contract.

Transaction cost economics states that the inter-firm level of contractual completeness, as defined above, reflects a desire by the parties to save transaction costs.

2.3. Previous empirical studies

As we mentioned in the introduction, few empirical studies are concerned with the contractual forms of inter-firm relationships. Even fewer specifically relate to the level of contract incompleteness chosen by contracting parties. The two main contributions are those of Crocker and Reynolds (1993) and Crocker and Masten (1991). They have shown that the transaction's characteristics pertaining to the contract are linked with the contractual incompleteness level chosen by the parties.

Nevertheless, (i) they both focus on one contract dimension — the price decision and (ii) they do not use direct measures of asset specificity at stake in the studied transactions when testing the transaction cost theory's propositions. For example, because of data limitations, Crocker and Reynolds only used data relating to the probability of each contracting party to behave opportunistically, instead of focusing on the level of asset specificity. Such a choice to proxy the willingness of the parties to be protected against opportunism is open to criticism (See Williamson, 1985, page 59 on this point).

We would like to go further on these two points by considering the contract form in its entirety and using more direct measures concerning the level of asset specificity at stake in transactions. Such an improvement would permit testing of a reduced-form (like in Crocker and Reynolds, 1993; Crocker and Masten, 1991), as well as a more structural form where characteristics of transactions are endogenized (Masten and Saussier, 2000).

2.4. The choice of contract incompleteness

It is natural to try to explain any observed contract as the outcome of an optimization process in which the relative benefits and costs of additional incompleteness are traded-off at the margin.[5] How will the transaction cost associated with the incompleteness level change?

Setting aside the cost of writing the agreement, the main costs incurred by the search for a more complete contract (as against a more incomplete one) will be the information cost, the negotiation cost, and the potential 'maladaptation cost' or 'renegotiation cost' of being trapped in a bad contract.[6]

The principal gains accruing from the establishment of a complete contract (as against a more incomplete one) are (i) for the contractant that has developed specific assets, a reduced exposure to the opportunism of the other party; (ii) savings on repeated negotiation costs. The probability of an *ex post* renegotiation is lower in a contract that aims for completeness. The more the contract specifies the transaction, the smaller the probability that the contract will be renegotiated. The incentive to invest *ex ante* is, therefore, greater (Grossman and Hart, 1986).

To understand how contracting parties make their choice, we need to identify the factors that influence the costs and gains of a contract that aims for completeness. In keeping with the methodology of transaction cost economics, we assume that these costs are mainly influenced by transaction characteristics. To understand how contracting parties make their choice, we need to identify the factors that influence the costs and gains of a contract that aims for completeness. In keeping with the methodology of transaction cost economics, we assume that these costs are mainly influenced by transaction characteristics.

1. What factors influence the costs of establishing a complete contract?

   The greater the uncertainty level of the transaction, the more difficult, expensive, and risky it will be to establish a contract that aims for completeness (particularly because of the potential costs of being 'trapped' in a bad contract).

   The marginal cost of completeness increases according to the completeness of the contract in consideration. The more complete a contract is, the more expensive it will be to add a contingency. The more precise a contract is, the more unimportant the unaccounted for contingency and the harder it will be to evaluate the contingency, because of the lack of experienced parties.

Proposition 1. *The marginal cost of a contract that aims for completeness increases with the transaction-uncertainty level and the contract-completeness level.*

2. What factors influence the gains resulting from a complete contract?

   A complete contract will be necessary, especially if there are incentives to have the parties be opportunistic. Such incentives are directly linked to the presence of specific assets that generate quasi-rent (Klein et al., 1978). The more complete a contract is, the lower the probability of an *ex post* negotiation, which is very uncomfortable for the contractant who has developed specific assets. When the parties aim for a complete contract to cover a transaction requiring the development of specific assets, this saves renegotiation costs in cases where the parties might be tempted to act opportunistically.

[5] In this section we get back to the contractual completeness model developped by Crocker and Reynolds (1993), but we focus on asset specificity level (instead of the probability to behave opportunistically) and we analyse the entire contract design (instead of focusing on price provision).

[6] Williamson argues that maladaptation costs are the most important costs one needs to take into account in understanding contract design (Williamson, 1996).

We assume the marginal gain from completeness decreases with the level of completeness because the final contingencies are less probable and exert a lesser incentive effect on the investment decision.

Proposition 2. *The marginal gain from a contract that aims for completeness increases with the appropriable quasi-rent at stake in the transaction and decreases with contractual completeness.*

We can represent the completeness decision as parameter p, with $p \in (0,1)$ reflecting the probability that one dimension of the transaction has to be specified *ex post* (if the contract is totally complete then $p=0$). The choice of contractual completeness by the parties can be illustrated in the following manner:

The marginal cost of establishing a more complete contract (for a given level of uncertainty $INC = \overline{INC}$) increases with the contractual completeness. The marginal gain from a more complete contract (for a given level of asset specificity $SPE = \overline{SPE}$) decreases with contractual completeness. The parties will choose the completeness level where the marginal cost equals the marginal gain.

An increase in the level of asset specificity ($\overline{\overline{SPE}} \succ \overline{SPE}$) involved in the transaction will shift the Gm curve upward (Gm′), increasing the chosen level of contractual completeness (move from p^* to p^{**} on Fig. 1). On the other hand, an increase in the uncertainty level will shift the Cm curve upward, decreasing the chosen level of contractual completeness.

This description of the trade-off assumes economic agents possess reasonably high calculation capacities. The latter is compatible with the bounded-rationality assumption that lies at the core of the transaction cost theory (Williamson, 1985). Without going so far as to claim that the parties make a complex cost-benefit analysis, we do believe that their choice is guided by a calculus approach, largely reflected in the trade-off described above.

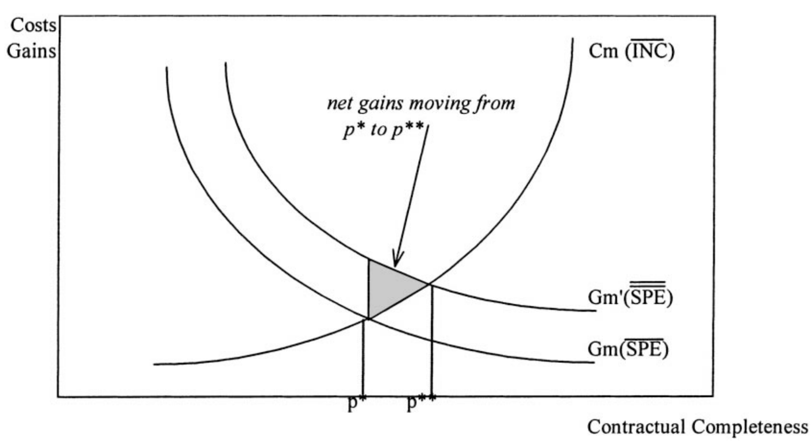

Fig. 1. The choice of contractual completeness.

3. Contracting in EDF coal procurement: an empirical test

To test the choice of inter-firm contractual completeness, we had to build our own database which consists of 29 contracts for the transportation of coal to EDF power plants. This exhaustive database 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 that has 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 high incentives and constraints. The EDF contracting office, specializing in coal contracts, is aware that electricity will continue to be produced with coal as long as coal is cheaper than alternative energy sources, essentially fuel and gas. That is why the office is constantly seeking to minimize production and transaction costs, and why it expressed interest in a study of its contractual completeness 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 imported coal, because we assumed such transactions are more likely to be driven by cost minimization. Although EDF also uses French coal, there are no transportation contracts for it: there is only one contract with the French State-owned railroad (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. The coal business also changed dramatically during the period studied, causing heterogeneity in the uncertainty levels tracked by our database. This was one reason 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 is well suited for use in testing of the theory's propositions.

3.1. Contract types

Carrier contracts are not very complex. They specify the duties and obligations of the parties in various ways, and with a varying number of dimensions.

A carrier contract can include:

1. minimum quantities that EDF must purchase;
2. minimum quantities that EDF's supplier must provide;
3. penalties in case of default by EDF;
4. penalties in case of default by EDF's provider;
5. price indexation[7] and
6. provisions for negotiations between the parties in the event of conflict (with or without third parties, in one or several rounds, with an exchange of letters, etc).

[7] Unlike many other countries, a contract is not legally valid in France unless it states the transaction price.

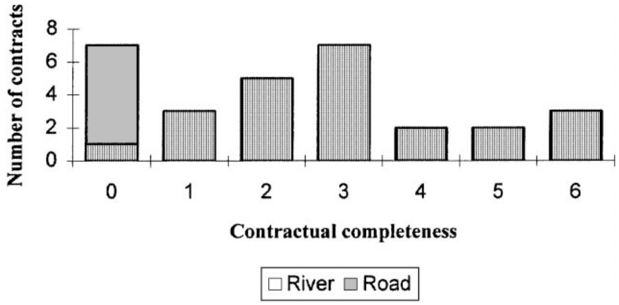

Fig. 2. Completeness of coal transportation contracts.

In order to econometrically test the level of completeness of these contracts, we classified them and created the variable NIVCOMP by rating the contracts in our possession from 0 to 6 following our definition of completeness, as defined (Fig. 2). Each contract scores one point if it specifies one of the dimensions listed above. A contract is rated 0 if it only specifies the transaction price. A contract is rated 6 if it specifies all the dimensions listed above. This variable reflects the willingness of the parties to sign a contract that clearly defines the transaction so as to avoid a possible renegotiation that could be motivated by rent-seeking behavior.

Several problems should be discussed here about the way to appreciate the level of contract completeness. First, unlike previous studies on the subject (Crocker and Masten, 1991; Crocker and Reynolds, 1993), we do not consider an incompleteness level for each contract dimension. It would be incorrect to do so if each contract dimension varied greatly from one contract to another. For example, a contract with a simple price indexation provision (rated one in our study) cannot be considered the same way as a contract with a very complex price provision.

However, in the case of EDF contracts, such variations do not exist.

1. When minimum quantities that EDF must purchase are defined, they are fixed quantities, without any indexation.
2. When minimum quantities that EDF's supplier must provide are defined, they are fixed quantities, without any indexation.
3. When penalties are specified, contracting parties usually follow the same rules, specifying the penalty level with consideration to the potential prejudice of the parties. That takes the form of take or pays for EDF, and the form of a general rule for providers, written in the contract as "if the provider does not respect delay, quantities for a period of time, EDF has the right to take a new provider, charging the defaulting provider for the cost differences that this change incurs."
4. When prices are not fixed, they are always indexed, following the same rule. They mainly incorporate the price evolution of the labor force and the fuel to transport coal.
5. The same is true for negotiation provisions. If such provisions exist, they always take the same form: exchange letters are organized to explain the sources of conflict. Several persons are designated to choose a conciliator;

if a conciliator is chosen, he must give his advice within three months, if not, each party chooses his own conciliator and the conciliators must either (i) choose a third conciliator or (ii) give common advice within one month.

If no conciliator can be chosen, it is stated that the President of the Paris commercial court will nominate one. The chosen conciliator gives his advice, after an exchange of letters [8] between the parties and the conciliator. This advice is followed or the parties may go to court.

Each contract provision does not exhibit great variation. Therefore, we believe the simplification of not considering an incompleteness level for each contract dimension is not too costly for our study. Instead, it permits us to easily consider a global incompleteness level.

The second problem with our measure is that the theory does not clearly state whether all provisions should be regarded as equally important (i.e. with a unit rating) or as independent of one another. One might have expected different weighting for each provision, but the theory tells us nothing on this point. That is why we chose a simple model of contractual completeness, but refinements are possible.

3.2. 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.

3.2.1. Physical assets

At some of its power plants, EDF had 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) and most other types of merchandise. The redeployment of EDF-specific barges would incur costs for several reasons. First, their particular shape is of no use to 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 'EDF barges' as specific physical assets that require the creation of a quasi-rent.To appreciate the level of physical investments made to meet EDF demands, we used the variable CAPA, which measures a carrier's transportation capacity, in thousands of cubic meters, and its ability to fulfil 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.

[8] Exchange letters are not private. All letters received by the conciliator must also be sent to the other party.

3.2.2. 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 elsewhere without cost (this constraint is referred to as site specificity).

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

3.2.3. Dedicated assets and human assets

We cannot arrive at a precise measure of 'dedicated assets' i.e., assets that cannot be redeployed because of market size. However, we know that they probably increased after 1992. The use of coal has fallen off sharply since then, causing a business downturn for EDF carriers. This poses a major problem for EDF [9], who has to decide whether to drop some of its suppliers or 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, nor could their general investments be viewed as dedicated physical assets. Today, with EDF accounting for so great a share of the carriers' business, both types of assets are increasingly specific [10]. After 1992, EDF choices could be treated as option-value decisions with irreversibility effects (Henry, 1974). In the post-1992 period, EDF did not have to produce electricity with coal. Nevertheless, it decided to keep carriers in business so as to preserve their expertise in case of system tension. This is an (expensive) way for EDF to postpone the decision on whether or not to drop its transportation providers.

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

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 (Williamson, 1993).

3.3. The uncertainty level: a period of change in contractual quantities

The contract database used for our study is valuable because of the heterogeneity of the asset specificity involved in the transactions. The period under review (1977–1997) is also of particular interest because of the changes in the exogenous disturbances affecting the transactions. This period can be split into two distinct sub-periods:

- 1977–1986: This is a period where disturbances existed, but were planned and were never too substantial. There was an increase in EDF demand (1977–1979), with a rise in quantities transported to and unloaded at EDF plants and a downturn in EDF de-

[9] Coal transportation slumped in 1987–1988, but the situation was not so problematic for EDF at that time because the overall level of transportation activity on French rivers was higher than in 1992–1997.

[10] 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 and could not exist without it.

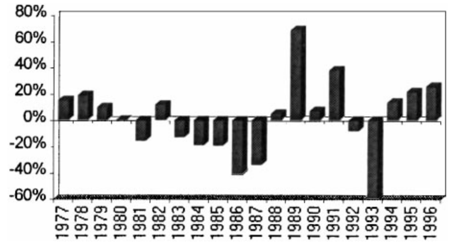

Fig. 3. (%)Annual changes in coal consumption.

mand (1980–1986), with a *planned* cutback in transported and unloaded volumes. This contraction was due to the growth of nuclear power.

- 1987–97: This is a period characterized by *unplanned fluctuations* in EDF demand, resulting in highly variable and hard-to-predict transported and unloaded volumes. Because of the growth in nuclear power, 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 (Fig. 3). The shocks were unpredictable and coal was used to fill temporary shortfalls.

We can, therefore, expect a difference between the 1977–1986 and 1987–1997 sub-periods in the transaction uncertainty regarding the quantities of coal to be supplied to EDF. The uncertainty increased in the 1987–1997 sub-period because the exogenous disturbances were larger, unplanned and more frequent than in 1977–1986. To take this change into account, we created a dichotomous variable, DUMMY87, with unit values for contracts signed between 1987–1997. The purpose of the dummy was to measure the changes in the chosen completeness of EDF contracts resulting from exogenous disturbances.

We did not identify other possible sources of uncertainty. Previous empirical studies have shown that uncertainty is sometimes due to transaction complexity, but this is not the case here. Coal transportation is an easy transaction to define. We did not identify any involvement of asset specificity in road contracts: these are signed during crises when the system is under tension and near the breaking point. In such situations, EDF has to provide coal to its plants, and is ready to do so at any price.

4. Empirical results

4.1. Expected results

The variables we created allow us to test the theory's proposition concerning the contractual completeness level Table 1.

Variables CAPA, SITEDEF 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 contractual completeness.

For the transaction uncertainty level, we use DUMMY87. We expect DUMMY87 to reduce contractual completeness.

Table 1
Variables and definition

Variables used	Definition
SITEDEF	Site investment in millions of francs divided by inflation index (1977=100)
CAPA	Transportation capacity, in thousands of cubic meters, created to satisfy EDF demand. Equals unity if on an EDF-specific route, 0 otherwise
DUMMY 92	Dichotomic variable equal to unity if contract signed between 1992 and 1997, 0 otherwise
DUMMY 87	Dichotomic variable equal to unity if contract signed between 1987 and 1997, 0 otherwise
ROAD	Dichotomic variable equal to unity for road contract, 0 for river contract

Table 2
Description of the variables

Variables	Obs.	Mean	Std. Dev.	Min	Max
NIVCOMP	29	2.41	1.95	0	6
SITEDEF	29	2.22	7.54	0	39.81
CAPA	29	2.013	6.179	0	30
DUMMY92	29	0.27	0.45	0	1
DUMMY87	29	0.82	0.37	0	1
ROAD	29	0.20	0.41	0	1

To measure the differences between road contracts and river contracts, we created the ROAD variable. This is a control variable, in order to correct for unobserved heterogeneities between road and river contracts Tables 2 and 3.

4.2. *Estimation results*

The ordinary least squares (OLS) are not entirely appropriate, because it implicitly assumes that NIVCOMP is a continuous variable and it does not take into account its ordinality (Maddala, 1983). We, therefore, use the OLS figures as reference points only (NIVCOMP(1) and NIVCOMP(2)), before estimating their relationship by means of an ordinate qualitative model (NIVCOMP(3) and NIVCOMP(4)). The results of an ordered logit estimation and an OLS estimation are basically the same. Results are consistent with transaction cost economics propositions. All coefficients have the expected sign, except for CAPA, which is non-significant instead of having a negative effect on contractual completeness. As we

Table 3
Correlation matrix

Variables	NIVCOMP	CAPA	SITEDEF	DUMMY87	DUMMY92	ROAD
NIVCOMP	1					
CAPA	0.25	1				
SITEDEF	0.49	0.25	1			
DUMMY87	−0.51	−0.01	−0.56	1		
DUMMY92	0.42	0.39	−0.10	0.28	1	
ROAD	−0.60	−0.16	−0.15	0.23	−0.31	1

expected, contracts signed in 1987–1997 are less complete than other contracts. On the other hand, contracts signed in 1992–1997 and involving site investments are more complete than others.[11] Road contracts are less complete than river contracts. That may be explained because of the emergency that characterizes such contracts. Estimates with river contracts alone are also presented (NIVCOMP(5) and NIVCOMP(6)). Our findings are consistent with the propositions derived from transaction cost analysis i.e., that contracting parties choose the level of completeness that will be most effective in minimizing transaction costs.

Transaction cost economics propositions are thus corroborated. 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).

4.3. 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 attempts to refute transaction cost economics ignore the possible endogeneity of asset specificity when testing the heuristic transaction cost model (Compare Williamson, 1985, chap. 4 and Riordan and Williamson, 1985) or avoid the endogeneity problem by estimating a reduced-form using proxies to reflect asset specificity levels at stake in transactions. These approaches, e.g. the one underlying Table 4 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 (1993, p. 27) is worth quoting: "To be sure, there is much to be done, hence there is no basis for complacency. . . most (empirical studies) are regressions in which asset specificity (and sometimes uncertainty and frequency) appear as independent variables". This point requires urgent attention in the development of empirical tests of the theory. Following Masten (1995, p. 60) we believe that "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."

To endogenize CAPA and SITEDEF, we propose several elements that should influence the willingness of the parties to invest in specific assets:

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

   We expect greater asset specificity in contracts for coal transportation on the Loire, because the river's sluices are larger than those on the Seine or 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 rather than take other routes to cut transportation costs. We, therefore, introduced two dichotomic variables: LOIRE,

[11] DUMMY92 and DUMMY87 have about the same coefficients. So it appears that the two opposite effects are equal in a contract signed between 1992 and 1997.

Table 4
Contractual completeness estimates (*t*-ratios in parentheses)[a]

	OLS	OLS	Ordered Probit	Ordered Probit	OLS	Ordered Probit
Independent variables	NIVCOMP (1)	NIVCOMP (2)	NIVCOMP (3)	NIVCOMP (4)	NIVCOMP (5)	NIVCOMP (6)
SITEDEF	0.14 (3.91)***	0.07 (2.18)**	0.40 (3.52)***	0.23 (1.72)*	0.07 (1.99)*	0.23 (1.72)*
CAPA	−0.035 (−0.69)	−0.025 (−0.73)	−0.01 (−0.37)	−0.018 (−0.454)	−0.025 (−0.67)	−0.018 (−0.45)
DUMMY92	2.06 (3.19)***	2.01 (3.99)***	1.77 (3.11)***	2.31 (3.14)***	2.01 (3.64)***	2.28 (3.10)***
DUMMY87	–	−2.17 (−3.43)***	–	−2.06 (−2.13)**	−2.17 (−3.13)***	−2.03 (−2.10)**
ROAD	–	−1.36 (−2.71)***		−1.96 (−2.77)***	–	–
CONST	1.62 (5.13)***	3.87 (7.01)***	0.6 (1.93)*	3.51 (3.31)***	3.87 (6.39)***	3.32 (3.11)***
Log likelihood	–	–	−38.9	−32.22	–	−28.09
Adj R^2	0.42	0.71	–	–	0.56	–
Pseudo R^2	–	–	0.26	0,40	–	0.31
Observations	29	29	29	29	23	23

[a] ***Denotes significance at 1% level; **denotes significance at 5% level; *denotes significance at 10% level; unstarred coefficients are not significant.

Table 5
Instrumental variables estimation[a]

Dependent variables	Obs.	R^2	Significant variables[b]
CAPA	29	0.42	DELTPUISS** (+)
SITEDEF	29	0.74	LOIRE*** (+), DELPUISS** (+)

[a] (Loire, Seine, Road, DELTCONS, DELTPUISS, dummy92, dummy87).
[b] *** denotes significance at 1% level; **denotes significance at 5% level.

equal to unity for contracts to transport coal on the Loire, and SEINE, equal to unity for contracts to transport coal on the Seine.

2. With the changes in coal consumption by the French power-generation industry and 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. With regards to the electrical output of the power plant concerned in the contract, each contract applies to a different plant, each with a different output. There are eleven coal-fired power plants in France, whose output ranges from 250 MW to 1800 MW. [12] To account for this, we introduced the variable DELTPUISS, which is equal to the output of the plant concerned in 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) Table 5.

We performed new estimates for NIVCOMP, by substituting the predicted values of CAPA and SITEDEF from the reduced-form estimations of these variables to the ordered probit model and then performed 2SLS. [13]

These results corroborate the theory's propositions (Table 6). Although CAPA is still non-significant, all the other coefficients display the predicted sign and are close to estimates where endogeneity bias is not corrected.

4.4. Choices simultaneity

Ideally, the final step in the analysis would be to estimate all contract provisions together in order to take into account their possible simultaneity. It would allow us to consider the possible links between contract provisions that define our completeness level Variable, and analysis of the links between the incompleteness level and other contract dimensions, such as contract duration [14] (Saussier (1997) for an attempt). As noted in

[12] The output for each plant, however, did not vary during the period studied. We, therefore, treat it as an exogeneous variable, as it was chosen well beforehand by EDF.
[13] Since the correction made little difference in the linear version of the model, using 2SLS instead of instrumental variables, we reported uncorrected standard errors in the ordered probit estimation.
[14] Contract duration varies greatly in our sample. From 1 month to 10 years. Long term contracts appear to be more complete (following our completeness definition) than short term contracts. For an economic analysis of this question, see Saussier, 1999.

Table 6
Contractual completeness estimates corrected from asset specificity endogeneity (*t*-ratios in parentheses)[a]

	2SLS	Two-stage ordered probit
Independent variables	NIVCOMP (7)	NIVCOMP (8)
SITEDEF	0.10 (2.19)**	0.11 (1.92)*
CAPA	−0.08 (−1.01)	−0.06 (−0.69)
DUMMY92	2.30 (3.45)***	2.58 (3.07)***
DUMMY87	−1.88 (−2.58)**	−2.28 (−2.45)**
ROAD	−1.36 (−2.54)**	−2.04 (−2.91)**
CONST	3.58 (5.51)***	3.73 (3.66)***
Log-Likelihood		
Adj R-squared	–	–
Observations	29	29

[a] **Denotes significance at 1% level; **denotes significance at 5% level; *denotes significance at 10% level.

Goldberg and Erickson (1987), because contractual provisions are chosen simultaneously and may interact, empirical studies should ideally estimate the whole of the contractual provisions. Nevertheless, because of data limitations, this problem is very hard to overcome (Masten and Saussier, 2000). Unfortunately, there is no model available to disentangle the dependency between the many contract provisions that constitute a contract. Transaction cost economics is of no help here. This point should be a top priority of future research.

5. Conclusions

There are now a wide number of incomplete contracting models that show how contractual incompleteness may influence the parties' incentives to invest in order to realize a transaction. They usually show how ex ante investments are distorted by such contracts. However, the level of contractual incompleteness is usually given in those models.

In this paper we use a transaction cost economics approach. We make the assumption that the level of contractual incompleteness is not given and may reflect the willingness of the contracting parties to economize on transaction costs. Our results show that parties' choice of contractual terms reflects a tradeoff between the specification costs and rigidities associated with specifying detailed performance obligations in uncertain transactions and the greater flexibility but higher expected cost of establishing the terms of ex post trade in less definite relational contracts.

A special emphasis has been put on how to test transaction cost economics propositions. We consider that empirical tests should be developed and refined to permit testing of all the theory's propositions and not only as is usually the case propositions derived from a 'heuristic' model (Williamson, 1985). Like other authors (Masten, 1995), we believe that future empirical tests will meet this challenge. We have shown one possible way in this article, by collecting more precise data allowing us to endogenize the asset specificity involved in each transaction.

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References

Al-Najjar, N., 1995. Incomplete contracts and the governance of complex contractual relationships American Economic Review 85, 432–436.

Bernheim, D.B., Whinston, M.D., 1998. Incomplete contracts and strategic ambiguity. American Economic Review 88, 902–932.

Crocker, K.J., Masten, S.E., 1991. Pretia ex machina? Prices and process in long term contracts. Journal of Law and Economics 34, 64–69.

Crocker, K.J., Masten, S.E., 1996. Regulation and administered contracts revisited: lessons from transaction cost economics for public utility regulation. Journal of Regulatory Economics 9, 5–39.

Crocker, K.J., Reynolds, K.J., 1993. The efficiency of incomplete contracts: an empirical analysis of air force engine procurement. Rand Journal of Economics 24, 126–146.

Goldberg, V.P., Erickson, J.E., 1987. Quantity and price adjustment in long-term contracts: a case study of petroleum coke. Journal of law and economics 30, 369–398.

Grossman, S.E., Hart, O.D., 1986. The costs and benefits of ownership: a theory of vertical integration. Journal of Political Economy 94, 691–719.

Hart, O.D., 1987. Incomplete contracts. In: Eatwell, Milgate, Newman (Eds.), The New Palgrave: A Dictionary Of Economics. Macmillan, London, pp. 752–759.

Hart, O.D., 1990. Is bounded rationality an important element of a theory of institutions? Journal of Institutional and Theoretical Economics 146, 696–702.

Hart, O.D., 1995. Firms, Contracts and Financial Structure. Oxford University Press, Oxford.

Hart, O.D., Moore, J.M., 1999. Foundations of incomplete contracts. Review of Economic Studies 66, 115–139.

Henry, C., 1974. Investment decisions under uncertainty: the irreversibility effect. American Economic Review 64, 1006–1012.

Holmstrom, B., Tirole, J., 1989. The theory of the firm. In: Schmalensee, Willig (Eds.), Handbook of Industrial Organization, Vol. 1. North Holland, Amsterdam.

Klein, B., Crawford, V.P., Alchian, A., 1978. Vertical integration, appropriable quasi-rents and the competitive contracting process. Journal of Law and Economics 21, 297–326.

Klein, P., Shelanski, H., 1995. Empirical research in transaction cost economics: a survey and assessment. Journal of Law Economics and Organization 11, 335–362.

Kreps, D.M., 1996. Markets and hierarchies and (mathematical) economic theory. Industrial and Corporate Change 5, 561–597.

Maddala, G.S., 1983. Limited Dependent and Qualitative Variables In Econometrics. Cambridge University Press, Cambridge.

Maskin, E., Tirole, J., 1999. Unforeseen contingencies, property rights and incomplete contracts. Review of Economic Studies 66, 83–115.

Masten, S., 1995. Empirical research in transaction cost economics: challenges, progress, directions. In: Groenewegen, J. (Ed.), Transaction Cost Economics and Beyond. Kluwer, Amsterdam.

Masten, S.E., 1999. Contractual choices, In: Boukaert, B., De Geest, G. (Eds.), Encyclopedia of Law and Economics. Edward Elgar Publishing and the University of Ghent (forthcoming).

Masten, S.E., Saussier, S., 2000. Econometrics of contracts: an assessment of recent developments in transaction costs economics. Revue d'Economie Industrielle (forthcoming).

Riordan, M.H., Williamson, O.E., 1985. Asset specificity and economic organization. International Journal of Industrial Organization 3, 365–378.

Salanié, B., 1997. Contract Theory: A Primer. MIT Press, Cambridge, MA.

Saussier, S., 1997. Contractual choices and transaction costs. Ph.D. Thesis, University of Paris, Panthéon-Sorbonne.

Saussier, S., 1999. Transaction cost economics and contract duration. Louvain Economic Review 65, 3–21.

Saussier, S., 2000. When incomplete contract theory meets transaction cost economics: a test on contract form. In: Claude Ménard (Ed.), Institutions, Contracts and Organizations: Perspectives From New Institutional Economics. Edward Elgar (forthcoming).

Schwartz, A., 1992. Legal contract theories and incomplete contracts. In: Werin, L., Wijkander, H. (Eds.), Contract Economics. Blackwell, Oxford, pp. 76–109.

Tirole, J., 1994. Incomplete contracts: where do we stand? Working Paper, Institut d'Economie Industrielle, Toulouse.

Williamson, O.E., 1975. Markets and Hierarchies: Analysis and Antitrust Implications — A Study in the Economics of Internal Organization. Free Press, New York.

Williamson, O.E., 1985. The Economic Institutions of Capitalism. Free Press, New York.

Williamson, O.E., 1993. The economic analysis of institutions and organisations — in general and with respect to country Studies. Working Paper No. 133, OECD.

Williamson, O.E., 1996, The Mechanisms of Governance. Oxford University Press, Oxford.