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CHANGING CONTRACT STRUCTURES IN THE INTERNATIONAL LIQUEFIED NATURAL GAS MARKET: A FIRST EMPIRICAL ANALYSIS

Mots-clés: Contrat à long terme, durée d'un contrat, coûts de transaction, coûts du contrat, gaz naturel liquéfié.

Key words: Long-Term Contract, Optimal Contract Duration, Transaction Cost Economics, Contracting Costs, Liquefied Natural Gas.

I. — INTRODUCTION

The future role of long-term contracts (LTCs) in the global energy sector is a major topic in recent policy debates. The discussion is fostered by the ongoing liberalization process in Continental Europe's natural gas and electricity markets in a period when import countries have encountered record-high prices, *e.g.*, crude oil has been traded in the US$ 140/bbl range in summer 2008 and LNG spot cargoes delivered to Japan were above US$ 19/MBTU in January 2008.

The dynamic factors affecting the global market for natural gas include: increasing competition for world reserves in a seller's market, realization of

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large-scale infrastructure investments (LNG as well as pipelines), new market entrants (countries as well as companies), and changes in trade structures. In the last five to ten years the global LNG industry has undergone rapid maturation. Changes in the institutional framework of downstream markets have moved the industry from monopolistic structures towards competition, thus stimulating fundamental changes in the organizational behavior of market participants. On the one hand we can observe vertical integration and strategic partnerships becoming commonplace, *e.g.*, ExxonMobil in cooperation with Qatar Petroleum controlling the entire value chain for LNG deliveries from Qatar to the UK, and on the other hand we can observe the increasing importance of LNG spot trade with natural gas hubs gaining in liquidity (2).

In the view of institutional economics, LTCs are considered a hybrid form of governance on the continuum between spot markets and full vertical integration. Typically, private oil and gas majors which participate in upstream projects or a consortium of the national oil/gas company and a private partner represent the transactor contracting for deliveries to downstream markets. LTCs have also experienced changes, such as decreased contract duration, diminished reliance on oil-price indexation in favor of gas-to-gas competition, and the relaxation or elimination of inflexible clauses, *e.g.*, take-or-pay or destination obligations. This paper analyses the determinants of contract duration in order to investigate the impact of market structure (*i.e.*, the level of competition on a regional as well as global level) on optimal governance choice.

Transaction cost economics, assuming bounded rationality of economic actors as well as asymmetric information, argues that LTCs are a tool to minimize transaction costs in bilateral relationships where relationship-specific investments occur with complex contracts functioning to overcome the *ex post* hold-up problem without integrating vertically (Williamson, 1975, 1985; Klein *et al.*, 1978). Empirical literature offers broad support for the proposition that economic actors choose organizational form and contract terms that promote efficient adaptation and minimize transaction costs. Masten (1999) provides a summary of studies investigating the determinants of contract duration and contract design. Pirrong's (1993) analysis on contracting practices in bulk shipping markets investigates differences in exogenous factors such as market structure or vessel specialization to explain the diversity of existing forms of governance. Whereas spot contracts are chosen in the absence of any bilateral dependency relationship, forward contracts are employed when significant temporal specificity is observed. In a specialized shipping market where both temporal and contractual specificities are present, LTCs or vertical inte-

(2) Whereas the share of short-term trade already has doubled from 10 % in 2000 to 20 % in 2008, a further increase to about 30 % is expected for the coming decade (IEA, 2008).

gration have proven to be the transaction cost economizing organizational structures.

Several empirical studies, most of which are based on a transaction cost framework, investigate the interrelation between contract duration and environmental characteristics. Empirical work on LTCs in the energy sector started during the 1980s. Joskow's path-breaking work (1985, 1987) investigating the relationship between specific investments and contract duration in the US coal industry shows that contracting parties make longer commitments when site-specific, physical asset-specific or dedicated investments occur. Saussier (1999) provides a first empirical study using European data on coal procurement accounting for the endogeneity of specific investments. He confirms that contract duration reflects the desire to save transaction costs ; duration increases with the level of appropriable quasi rents at stake in the transaction, and decreases with the level of uncertainty. Investigating coal contracts, Kerkvliet and Shogren (2001) find a positive relationship between physically specific investments and contract duration and show that the duration decreases with rising trading and market experience. Saussier (2000) adds a new dimension *via* testing the influence of transaction parameters on the level of completeness of French coal supply contracts, accounting for endogeneity of asset specificity. He shows that the completeness of contracts increases with the level of specific investments and decreases with the level of uncertainty.

A number of studies investigating the natural gas sector discuss contractual relations in different institutional settings. Hubbard and Weiner (1986) analyze long-term natural gas supply contracts between producers and pipelines following the deregulation of wellhead prices in the US and derive a theoretical model on the determination of take-or-pay provisions. Crocker and Masten (1988) discuss and test the impact of regulatory actions on contract duration to show that distortions in performance incentives raise the hazards of long-term agreements and therefore shorten contract duration. Neuhoff and Hirschhausen (2005) discuss the role of long-term natural gas contracts in markets undergoing liberalization. They show that both strategic producers and consumers benefit from lower prices and a higher market volume if long-run demand elasticity is significantly higher than short-run elasticity. Hirschhausen and Neumann (2008) provide an empirical analysis of the changing contract structure in international natural gas trading. They find that contract duration decreases as market structure evolves to more competitive regimes and provide further empirical support for transaction cost economics by showing that investments linked to specific infrastructures increase contract duration by an average of three years.

Whereas the early literature focusing on the natural gas sector is based on the US market, Hirschhausen and Neumann (2008) provide the first study using international trade data. Our contribution to the literature is the first empirical assessment focusing on long-term *liquefied* natural gas supply contracts. In contrast to traditional pipeline infrastructures there is no locational specificity of investments resulting from technical characteristics since trades between varying players theoretically are feasible. The market structure has changed dramatically during the past decade ; the survival of incumbents as well as new entrants strongly depends on their ability to act economically ; strategic decisions (of private sector players) are driven by cost minimization. The heterogeneity of transactions in terms of varying levels of relationship-specific investments and external uncertainty should be matched by diversity in forms of governance (varying levels of vertical integration ; varying characteristics and duration of supply contracts, etc.).

For these reasons, our data are particularly well-suited to test transaction cost theory's propositions. We discuss the determination of the optimal contract length as a trade-off between the minimization of transaction costs due to repeated bilateral bargaining and the risk of being bound by an inflexible agreement in uncertain environments. Furthermore, we add to the theoretical discussion an analysis of different dimensions of transaction frequency and their impact on governance choice.

Building a two-stage estimation model to account for endogeneity of the contracted volume, we empirically test propositions i) on the above mentioned trade-off with LTCs securing durable investments but forgoing some flexibility, and ii) on the influence of transaction frequency (within the relationship as well as between the trading partners) on contract duration. Estimation results using a unique dataset including information of LNG supply contracts from the beginning of the industry until today show that the presence of high, dedicated asset specificity in LNG contracts results in longer contracts, confirming the predictions of transaction cost economics. The need for flexibility in today's « second generation » LNG market supports shorter-term agreements. Contract duration decreases when firms have experience in bilateral trading. In addition, we find that countries heavily reliant on natural gas imports *via* LNG are often willing to forgo some flexibility in favor of supply security. Contracts dedicated to competitive downstream markets on average are shorter than those concluded with customers in non-liberalized import markets.

The paper is organized as follows : Section II discusses the theoretical background and derives testable hypotheses and Section III introduces the industry-specific context. Section IV summarizes the dataset and introduces the methodology. We present and interpret estimation results in Section V before concluding in Section VI.

II. — THEORETICAL BACKGROUND

II.1. Optimal contract duration – a trade-off

The trade-off between contracting costs and flexibility is discussed in theory and investigated in a number of empirical papers (*e.g.*, Gray, 1978 ; Crocker and Masten, 1988; Klein, 1989; Klein *et al.*, 1990; Heide and John, 1990). Transaction cost economics predicts that investments in idiosyncratic assets result in *ex post* bilateral dependency and lead to a lock-in situation where the investor faces the hazard of post-contractual opportunism and strategic bargaining by the counterparty. In such settings longer-term agreements attenuate those costs by stipulating the terms of trade over the life of the contract. Yet contract duration is limited due to uncertainty about the future and the hazard of being bound by an agreement that may no longer reflect market realities; obviously, spelling out every contingency is costly or even impossible. Hence, the trade-off lies in choosing « terms that maintain incentives for efficient adaptation while minimizing the need for costly adjudication and enforcement » (Crocker and Masten, 1988, p. 328).

The optimal level of contract duration τ^* corresponds to a situation where the marginal costs and benefits of contracting are equal. The costs of being bound by the contract are determined mainly by the level of uncertainty and will increase with duration. Uncertainty about the future is higher for more distant time horizons; parameters that are fixed in the short-term become variable in the long-term. Hence, stipulated terms may be inefficient in later periods and marginal costs increase with uncertainty and contract duration. We note that the presence of uncertainty also raises the costs of bargaining; however, the costs of contracting increase to a greater extent since the parties must account for all (known) possible contingencies.

The benefits of avoiding repeated negotiation are chiefly determined by the level of idiosyncratic investments dedicated to the trading relationship. Longer-term agreements support the willingness of the party to take actions whose values are conditional upon the counterparty's post-contractual behavior; the costs of repeated bargaining are eliminated. Marginal benefits decrease with contract duration. Figure 1 illustrates the optimization problem. An increase in the level of uncertainty (u'' > u) will result in an upward shift of the marginal cost curve; an increase in the level of asset specificity (s' > s) will result in an upward shift of the marginal benefits curve, and both move the optimal level of contract duration.

We can formalize the discussion above by the optimization problem: $\max_{\tau} G(\tau)$ with $G(\tau) = B(\tau) - C(\tau)$ with G being the net gains in transaction costs which equal the difference between the benefits of contracting B and the costs of contracting C (both, *ex ante* as well as *ex post*). The first order condition yields:

$$\begin{aligned} G'(\tau) &= MB(\tau) - MC(\tau) = 0 \\ MB(\tau^*) &= MC(\tau^*) \end{aligned} \tag{1}$$

with optimal contract duration determined by the setting where marginal benefits equal marginal costs. Since it is difficult to observe and measure contracting costs, we construct a reduced form model where the marginal cost and marginal benefits of contracting are related to observable contracting attributes:

$$MB(\tau^*) = MB(\tau,s,\nu) = \alpha_0 - \alpha_1\tau + \alpha_2 s + \nu$$
$$MC(\tau^*) = MC(\tau,u,\omega) = \beta_0 + \beta_1\tau + \beta_2 u + \omega \quad (2)$$

with τ being the length of the agreement, s the level of specific assets dedicated to the trading relationship, u the level of uncertainty and ν and ω further explaining attributes such as unobserved heterogeneity between the parties, or environmental characteristics. Substituting (2) into (1) and rearranging yields the reduced form:

$$\tau^* = \gamma_0 + \gamma_1 s - \gamma_2 u + \varepsilon \quad (3)$$

$$\text{with } \gamma_0 = \frac{\alpha_0 - \beta_0}{\beta_1 - \alpha_1},\ \gamma_1 = \frac{\alpha_2}{\beta_1 - \alpha_1},\ \gamma_2 = \frac{\beta_2}{\beta_1 - \alpha_1},\ \varepsilon = \frac{\nu - \omega}{\beta_1 - \alpha_1}$$

with optimal contract duration on the left hand side of the equation and contracting attributes on the right. From the discussion above we derive the following propositions:

Proposition 1a: Contract duration should increase with the level of investments in idiosyncratic assets to avoid repeated bilateral bargaining and mitigate the *ex post* hold-up problem between the contracting parties.

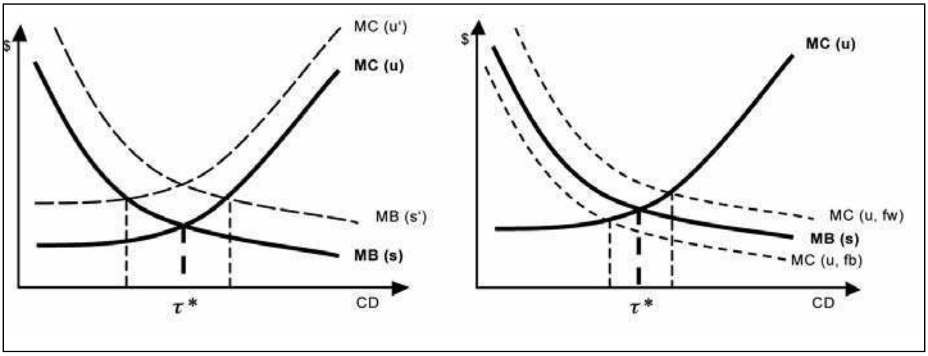
Proposition 1b: Higher environmental uncertainty should reduce contract duration to minimize the risk of being bound by a long-term commitment that no longer reflects market realities.

II.2. Hypotheses on the impact of transaction frequency

Transaction cost theory argues that transaction costs increase with the frequency of the transaction within the trading relationship due to the repeated hazard of opportunistic behavior and potential strategic renegotiation, which increases the incentive to organize the transaction under stronger internal control. Thereby, the contracting parties anticipate *ex ante* the total number of future transactions and decide on contract design, taking into account transaction frequency. An alternative explanation for a high frequency resulting in more firm-like governance structures is the greater potential for internal specialization and for exploiting scale economies (see *e.g.*, Williamson, 1985).

However, another perspective looks at the number of settlements in which similar transactions by the same parties occur. First, faithful partners may be rewarded and opportunistic behaviors punished in such long-term relationships. Second, there may be a decrease in transaction costs due to learning processes, established routines, and reputational effects (see *e.g.*, Milgrom and

FIGURE 1 : Optimization problem – (1) original form and (2) including transaction frequency



Roberts, 1992), all of which reduce the need for formal mechanisms to enforce bilateral agreements. See Gulati and Nickerson (2008) for a deeper discussion on the impact of inter-organizational trust on governance choice and firm performance. A high transaction frequency therefore should result in shorter contracts. Garvey (1995) develops a model investigating the effect of reputation on governance choice in settings where non-contractible investments occur. He finds that integration is favored for one-shot games whereas more hybrid structures like joint ventures are preferred in repeated games. He argues further that reputational considerations have an effect on both the parties' surplus and the optimal choice of asset ownership.

We argue that these two perspectives on transaction frequency are complementary and expand the above developed model (3) including two frequency measures: *fw* indicating the frequency of the transaction *within* the relationship and *fb* indicating the historical frequency of transactions *between* the same trading partners expecting a positive (respectively negative) relationship with contract duration:

$$\tau^* = \gamma_0 + \gamma_1 s - \gamma_2 u + \gamma_3 fw - \gamma_4 fb + \varepsilon \qquad (4)$$

With increasing « within frequency » the costs of contracting will rise due to the repeated hazard of opportunistic bargaining; with increasing « between frequency » the costs of contracting will fall due to lower *ex ante* as well as *ex post* transaction costs (see also Figure 1). We therefore derive the following propositions:

Proposition 2a: Contract duration should increase with the level of frequency of the transactions within the trading relationship to avoid the repeated hazard of post-contractual opportunism by the non-investing party.

Proposition 2b : Contract duration should decrease with the frequency of transactions between the same trading partners due to learning and reputational effects.

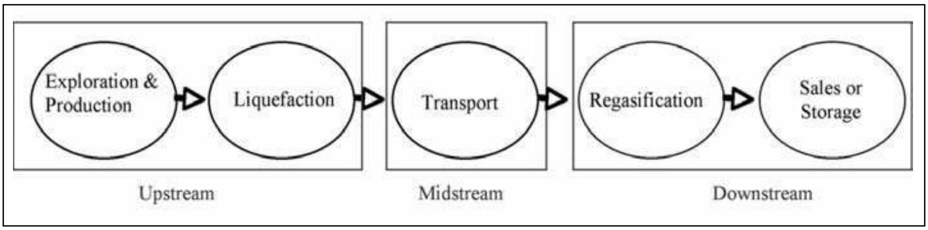
III. — INDUSTRY CONTEXT

During the 1980s and early 1990s, indigenous natural gas supplies and imports *via* pipeline were sufficient to meet demand in the Atlantic Basin, and LNG capacities grew relatively slowly. In contrast, Pacific Basin importers (mainly Japan, South Korea, and Taiwan) lacking large domestic energy supplies and pipeline sources historically relied upon LNG imports. Figure 2 depicts the three stages of the LNG value chain : upstream exploration, production and liquefaction, midstream transportation (*i.e.*, shipping) and downstream regasification, storage and marketing.

Converting natural gas to LNG for transportation by tanker has been utilized for more than 40 years, but the industry achieved a remarkable level of global trade only recently. As early as 1964, the technology of natural gas liquefaction enabled commercial transport in tankers, but transport remained expensive and markets stayed regional in nature until the 1990s. During this early stage, most of the world's LNG export infrastructure remained under state control and private or foreign companies were rarely involved. Inflexible bilateral long-term contracts with take-or-pay and destination clauses secured infrastructure investments and reliable supplies for import-dependent buyers.

Since the 1990s, investments in LNG infrastructure grew rapidly as worldwide natural gas demand increased, leading to substantial economies of scale throughout the value chain ; tanker financing and construction schedules benefited from new manufacturing techniques. Today's large ships reduce average transport costs ; break-even of pipeline and LNG transport is achieved at about 3,000 km (Jensen 2004). Investment costs for the entire value chain can be up to US$ 5 billion with upstream exploration and production accounting for the largest share (about 55 %). Today, LNG supplies the US, the UK, Spain, South

FIGURE 2 : LNG value added chain



Korea, India, and China among others. Importers compete for supplies in a seller's market. The Middle East accounts for more than 40 % of worldwide proven natural gas reserves and is expected to become the largest exporter of LNG. It is currently evolving to a swing producer; deliveries to European and Asian markets and even to North America are feasible without a significant difference in (transportation) cost.

Changes in the institutional framework demand fundamental changes in the organizational behavior of market participants in this « second generation » LNG market. More competition, mirrored by functioning spot markets, a gain in contract flexibility, and increasing international trade, exposes traditional players to greater pressure. Global mergers and acquisitions, integration, and strategic partnerships have become routine and the industry is dominated by a small number of large, powerful players. Several authors provide perspectives on the emerging corporate strategies being employed, *e.g.*, Cornot-Gandolphe (2005) and Iniss (2004) indicate that long-term contracts are increasingly accompanied by flexible short-term agreements (3). Shorter and/or more flexible contracts support arbitrage trade with deliveries dedicated to the highest value market.

Average contract duration including pipeline and LNG deliveries has shortened; whereas traditionally 25 years was common, newer agreements typically are 8 to 15 years for contracts supplying Europe *via* pipeline and 15 to 20 years in Asia (IEA, 2004). Importers with strong seasonality in consumption (*e.g.*, Spain, South Korea) increasingly agree on short-term deliveries up to several months to meet seasonal variations. Our contribution to the literature is a richer analysis of the determinants of contract duration of long-term LNG supply contracts accounting for the trade-off between the minimization of transaction costs in terms of searching for contracting partners and (re)-negotiating *versus* the mal-adaptation costs of deviations from the expected developments of decision parameters (input or output prices, product demand, transportation costs, etc.) as well as on the impact of transaction frequency.

The next section develops a reduced form empirical model that allows us to test for the significance of measures of asset specificity, the need for flexibility and transaction frequency in LNG supply contracts.

(3) To secure large-scale infrastructure investments (*i.e.*, liquefaction terminals), long-term supply contracts concluded before the construction process today still play an important role. However, a number of recent projects show that some companies invest without total output capacity committed to an LTC, *i.e.*, a share of the capacity is employed in more flexible trade (*e.g.*, Oman LNG; Woodside's Pluto LNG in Australia).

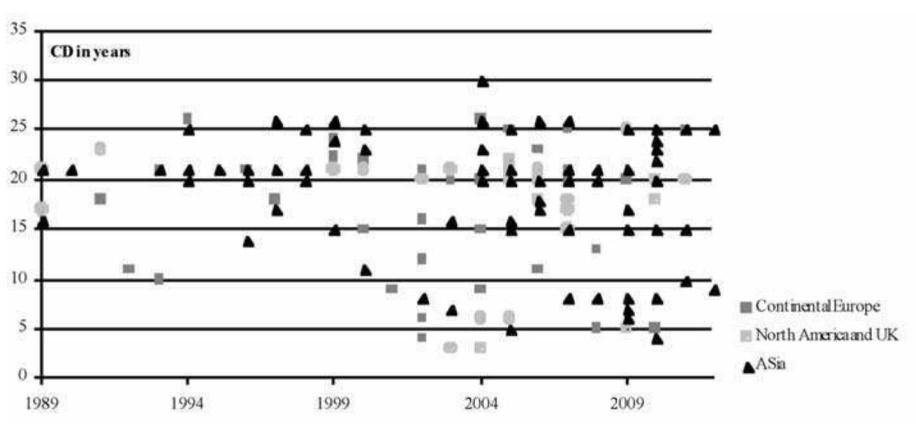
IV. — DATA AND METHODOLOGY

IV.1. Data

While most empirical work investigating LNG contracts is based on case studies (*e.g.*, Rigby and Catoya, 1999), we compiled a global dataset covering long-term agreements from the beginning of the industry in the 1960s until today from various publicly available information such as periodical reports, newsletters, and industry journals – supporting an econometric analysis. It includes amongst others contracting parties, annual and total contracted volumes, year of contract signature, start date of deliveries and contract duration. Both, contracts currently in place or agreed for with the start of delivery during the coming years and contracts that already have been terminated are incorporated (4). We estimate that the dataset covers at least 80 % of all ever existing long-term LNG supply contracts.

Omitting observations with implausible data and contracts with durations of less than three years (since these have the character of short-term agreements in the LNG industry), the sample consists of 261 LNG supply contracts, of which 105 correspond to Atlantic Basin trade and 156 to Asia-Pacific deliveries. By omitting further observations where not all later defined variables could be specified, the final sample consists of 224 observations (see Figure 3). Contract duration of these agreements varies between three and

FIGURE 3 : Contract duration and start of deliveries of the 224 LTCs in the sample



(4) Since our dataset includes both contracts currently in place and contracts that already have been terminated, this study does not suffer from a truncated dependent variable as discussed in several other empirical papers investigating the determinants of contract duration (*e.g.*, Joskow, 1987; Crocker and Masten, 1988).

30 years and is typically in the range of 15 to 30 years in the early decades of the industry. In the past decade the number of agreements with less than 20 years and even less than ten years duration increased. Average contract length for agreements starting delivery *prior* to the year 2000 is 20.3 years in our sample; for contracts starting delivery from 2000 on it is 16.7 years (5).

The unit of analysis for studying the determinants of contract duration is an LNG supply contract concluded between an upstream seller (company or consortium) and a downstream buyer. Transactions are defined as cargo deliveries of LNG. The endogenous variable is contract duration in years. For the purpose of this study we assume a sample of contracts that holds constant other contract provisions, such as price adaptation or renegotiation clauses. Unfortunately, the existence and utilization of such provisions is held confidentially by the trading partners and cannot be accounted for in this analysis.

IV.2. Explanatory variables

Asset specificity. Asset specificity varies across the transactions in the industry; in our case it refers to the degree to which an LNG import terminal is not redeployable. The characteristic of a seller's market accompanied by restructuring and liberalization of downstream natural gas (and electricity) markets results in downstream asset specificity. A player investing in regasification capacity without having secured supplies and access to midstream shipping is caught in a lock-in situation. LNG sellers profit from significant bargaining power since importers compete globally for supply; furthermore, competitive downstream markets provide easy access to numerous buyers. To quantify the level of idiosyncrasy (*i.e.*, relationship-specific investments) (6) we use the ratio to which the contract exploits the nominal capacity of the import terminal (*RCAPSHARE*) as a proxy. A buyer relying on a single supplier for a large volume of deliveries will have difficulty replacing these supplies if they are terminated suddenly in an illiquid market such as the LNG market, where only very limited free capacities (upstream supplies as well as midstream ships) are available.

(5) Differentiating between importing regions, average contract duration in Continental Europe has been 20 years (16.9 years), in the more competitive natural gas markets of North America and the UK 20.5 years (16.1 years), and in Asia 20.3 years (16.9 years) before and from the year 2000 on respectively based on our dataset.

(6) Transaction cost economics distinguishes between physical asset, site, dedicated, human, intangible, and temporal specificities. However, in the LNG industry, site specificity only matters upstream between production facilities and the liquefaction terminal, which generally are controlled under one and the same national company or consortium. We observe dedicated assets since traditionally, investments in upstream, midstream, or downstream capacities are safeguarded by *ex ante* contracting on a major portion of the nominal export and import capacities. Physical asset specificity relates to the importance of a specific supplier to an import facility. Human, intangible and temporal specificities are less relevant for our analysis.

Uncertainty. Uncertainty is a broad concept; Klein (1989) distinguishes between complexity and unpredictability; Williamson (1985, p. 57) states that « disturbances… are not all of a kind. Different origins are usefully distinguished ». We focus on external uncertainty components measuring environmental dynamism (*i.e.,* price uncertainty, political instability in the exporting country, and general environmental uncertainty). The unexpected occurrence of contingencies can motivate players to behave opportunistically (*e.g.,* in the case of *ex post* maladaptation).

We employ the standard deviation of West Texas Intermediate crude oil spot prices (*STDEVOIL*) in the year before contract signature, calculated based on daily data, since oil prices traditionally influence natural gas prices *via* oil-linkage in pricing formulas. Even though oil-linkage is substituted step by step in preference to gas indexes that reflect gas-to-gas competition, this variable still continues to be an adequate measure of price uncertainty. We add a second variable for political uncertainty in the exporting country (*UNC*) based on POLCON (Henisz, 2000); this index measures the degree of constraints on policy change in a country averaged for five-year periods since 1960 (7). We then add a third variable to account for a firm's need for flexibility. Whereas the early industry relied on inflexible, predictable, bilateral buyer-seller relationships, the industry today is characterized by major changes and a specific unpredictability about the future: formerly regional markets become linked, new players (*i.e.*, countries and firms) enter the industry, liquid trading hubs gain importance, numerous companies invest in a portfolio of export and import positions to be able to benefit from arbitrage potentials. Empirical research provides evidence that we can distinguish the « infant » (1960s to 1990s) from the « mature » (from 2000s on) industry (Ruester and Neumann, 2009). We use a dummy variable indicating LNG supply contracts that became operational after 1999 (*D2000*), expecting a negative relationship between D2000 and CD.

Transaction frequency within the relationship. To measure the frequency of transactions within the trading relationship (*i.e.*, within the LNG supply contract) we employ the annual contracted volume (*VOL*) assuming that contracts are fulfilled according to their specifications. Since the standard sizes of LNG vessels range from 130,000 to 145,000 m^3, the annual contracted volume provides a good indicator for the frequency of shipments within the contract over a given period.

(7) Various studies have shown the suitability of this index for political uncertainty. We adjust the POLCON index so that a high value expresses high uncertainty and a low value low uncertainty; hence our proxy variable UNC is defined as (1-POLCON). Henisz (2000) reports POLCON indexes until the period 1990-1994. For observations after 1995 we use the most recently reported value which is an appropriate assumption, since the index is very stable over the reported period.

Transaction frequency between the trading parties. Gulati and Sytch (2008) point out that the history of prior interaction is the most important factor determining inter-organizational trust. We employ three alternative variables indicating the historical trading experience between the same trading partners assuming that repeated negotiation of LNG supply contracts reduces *ex ante* as well as *ex post* contracting costs. Transaction costs diminish due to learning processes; contracting parties gain information about each other's behavior; reputational aspects reduce the hazard of post-contractual opportunistic behavior. First, we define a count index indicating the cumulative number of LNG trade relationships between supplier and buyer (*BILEXP1*). Thus, if the parties negotiate a contract for the first time the variable will be one; for a second contract between the same parties it will be two, and so on. Second, we use a similar count index indicating the cumulative number of years of bilateral LNG trade (*BILEXP2*). Third, we include a dummy variable equaling one if the contract represents a contract renewal (*RENEW*) instead of the first trading relationship between the same parties.

Control variables. We include the buyer country's LNG share in total imports (*LNGSHARE*) to account for varying supply structures. While countries like the US can import natural gas via pipeline and LNG plays only a minor role in total gas supplies, South Korea or Japan rely heavily upon imports. The higher the share of LNG in total imports the higher should be the duration of supply contracts. We define a dummy variable indicating contracts dedicated to competitive downstream markets (*COMP*) assuming that only the markets in the US and the UK can be regarded as liquid and competitive. This variable equals one if the contract became operational in periods of unbundled transportation infrastructures (*i.e.*, after 1992 for the US and after 1997 for the UK), since unbundling of the monopolistic element of the value chain is an essential precondition for non-discriminatory access to infrastructures and free market entry.

Instrumental variables. To account for endogeneity of a right-hand side variable (*i.e.*, contracted volume) and conduct two-stage estimation of simultaneous equations we need to include instrumental variables. We use the level of self-sufficiency of the importing country (ratio of domestic natural gas production over total consumption, *SELFSUFF*), the nominal capacity of the import terminal (*CAP*), and the number of import terminals in the respective country in the year LNG deliveries under the respective contract began (*TERMINALS*). The correlation matrix (see Table 2) supports the choice of these variables, since they weakly correlate with contract duration and more with the annual contracted volume. For an alternative model accounting additionally for the endogeneity of the level of relationship-specific assets we include a dummy variable indicating value chains which operate in the Atlantic Basin (*ATLANTIC*).

For a survey of all exogenous variables as well as their descriptive statistics see Table 1, next page. More than half of the contracts of our dataset (70 %)

TABLE 1 : Descriptive statistics

Characteristic	Proxy	Unit	Denotation	Exp. Sign	Mean	Std. Dev.	Min	Max	N
Propositions 1a and 1b									
Specificity	Ratio to which the contract exploits the nominal capacity of the import terminal	%	RCAPSHARE	+	0.208	0.248	0.002	1	224
External uncertainty and need for flexibility	Political instability in the supplying country		UNC	-	0.591	0.389	0	1	224
	Standard deviation of WTI crude oil spot price in year before contract signature		STDEVOIL	-	3.778	2.733	0.874	12.85	224
	Start-up deliveries > 1999	Dummy	D2000	-	0.696	0.461	0	1	224
Propositions 2a and 2b									
Within frequency	Annual contracted volume	bcm/a	VOL	+	1.733	1.476	0.03	6.75	224
Between frequency	Cumulative number of contracts negotiated between the two parties	Count	BILEXP1	-	1.728	1.299	1	9	224
	Cumulative number of years of trading relationship between the two parties	Count	BILEXP2	-	5.330	8.598	1	30	224
	Contract representing a contract renewal	Dummy	RENEW	-	0.156	0.364	0	1	224
Control variables									
Dependence on LNG	LNG share in total natural gas imports	%	LNGSHARE	+	0.695	0.380	0.03	1	224
Downstream competition	Contract dedicated to competitive downstream market (*i.e.*, US from 1992 ; UK from 1997)	Dummy	COMP	-	0.147	0.355	0	1	224
Instruments									
Self-sufficiency	Domestic production/total consumption	%	SELFSUFF		0.219	0.375	0	1	224
Import terminal capacity	Nominal capacity of regasification terminal	bcm/a	CAP		18.908	18.906	0.21	75	224
Number of import terminals	Number of import terminals in import country	Count	TERMINALS		11.031	10.018	1	29	224
Atlantic Basin value chain	Contract destined to Atlantic Basin customers	Dummy	ATLANTIC		0.411	0.493	0	1	224

started delivery from 2000 on, mirroring the expanding international LNG trade during the last decade. The contracts account for 0.2 % of the import terminal capacities (deliveries from Australia to Japanese customers) and up to 100 % (deliveries from Nigeria to Italy). The political uncertainty index of the exporting countries ranges between zero and one with a mean of 0.59 ; the standard deviation of the WTI crude oil spot price in the year before contract signature varies strongly between 0.87 and 12.85 for recently concluded contracts. Annual contracted volume is between 0.03 (deliveries from Australia to Japan) and 6.75 bcm/a (planned deliveries from Iran to India). The negotiating parties in most cases bargained for the first time; however, bilateral experience for single players shows values of up to nine (Gaz de France and Algerian Sonatrach) and we observe previous trading experiences of up to 30 years. 16 % of the contracts in our database represent renewals of expired agreements. The dataset involves both highly self-sufficient (*e.g.*, US and UK) and LNG import-dependent (*e.g.*, Japan and South Korea) countries. In 15 % of the observations, deliveries are dedicated to competitive downstream markets. The nominal capacity of the import facilities varies between 0.21 (Nippon's Kagoshima terminal) and 75 bcm/a (Tepco's import portfolio in Japan). The number of import terminals per country in the delivery start-up year is between one (*e.g.*, Belgium, Greece, Turkey) and 29 (Japan as of today).

IV.3. Methodology

To test our propositions, we define the following estimation model with contract duration as the endogenous variable:

$$CD_i = \phi_0 + \phi_1 RCAPSHARE_i + \phi_2 UNC_i + \phi_3 STDEVOIL_i + \phi_4 D2000 + \phi_5 VOL_i + \phi_6 BETWFREQ_i + \phi_7 LNGSHARE_i + \phi_8 COMP_i + \varsigma_i \quad (5)$$

where i indexes contracts and the error term ς_i is assumed to be i.i.d. We estimate three models including only one of the alternative measures of the frequency of transactions between the same trading partners (BETWFREQ in Equation 5) at a time to avoid multicollinearity problems with: a) ln(BILEXP1), b) ln(BILEXP2), and c) RENEW. Based on a first regression analysis including BILEXP1 and BILEXP2 in linear as well as quadratic form we found a nonlinear relationship between each of these variables and CD; therefore we include the logged values in the estimation model.

However, contract duration and contracted volume are determined simultaneously when an LNG seller and buyer agree upon a supply arrangement. Therefore, we estimate the model applying two-stage least squares (2SLS) and verify estimation results using the generalized method of moments (GMM) procedure (8) with:

(8) GMM is a robust estimator; no information on the exact distribution of the disturbances is required. In our case the estimation is based on the assumption that the error terms are uncorrelated with the set of instrumental variables.

$$VOL_i = \theta_0 + \theta_1 RCAPSHARE_i + \theta_2 UNC_i + \theta_3 STDEVOIL_i + \theta_4 D2000 + \theta_5 BETWFREQ_i + \theta_6 LNGSHARE_i + \theta_7 COMP_i + \theta_8 SELFSUFF_i + \theta_9 CAP_i + \theta_{10} TERMINALS_i + \xi_i \quad (6)$$

as the second equation in the system with ξ_i again assumed to be i.i.d.

V. — ESTIMATION RESULTS AND INTERPRETATION

Tables 2 and 3 present estimation results of the simultaneous equation system. Three models (A, B, and C) are estimated including one of the above defined measures for historical transaction frequency between the same partners. 2SLS and GMM estimation lead to similar results; for comparative reasons we include estimation results of a simple OLS model treating the contracted volume as an exogenous variable. Propositions 1a, 1b and 2b can be confirmed empirically. The p-values of F-statistics (all < 1 %) show that the null hypotheses of all slope coefficients equaling zero must be rejected for all estimations. Adjusted (respectively centered) R^2 of 2SLS (GMM) for the equations explaining contract duration is between 0.21 and 0.30.

The transaction cost prediction of **Proposition 1a** is confirmed for the variable indicating the ratio to which the contract exploits the nominal capacity of the import terminal (RCAPSHARE). The more important the contract to the import terminal, and therefore the higher asset specificity, the longer the duration to mitigate *ex post* hold-up. Buyers relying strongly on one supplier prefer longer-term contracts. In addition, since the level of the coefficient is

TABLE 2 : Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CD	1	1														
RCAPSHARE	2	0.22	1													
UNC	3	-0.04	0.16	1												
STDEVOIL	4	-0.21	-0.01	0.00	1											
D2000	5	-0.27	0.09	0.09	0.37	1										
VOL	6	0.23	0.56	0.13	0.03	0.13	1									
BILEXP1	7	-0.27	-0.26	0.07	0.11	0.01	-0.14	1								
BILEXP2	8	-0.26	-0.30	0.03	0.06	-0.04	-0.09	0.84	1							
RENEW	9	-0.32	-0.18	0.06	0.07	-0.01	0.01	0.66	0.78	1						
LNGSHARE	10	0.12	-0.37	-0.27	-0.05	-0.18	-0.21	0.11	0.29	0.14	1					
COMP	11	-0.18	0.21	0.01	0.02	0.25	0.08	-0.19	-0.23	-0.18	-0.59	1				
SELFSUFF	12	-0.01	0.54	0.05	0.16	0.24	0.30	-0.26	-0.31	-0.19	-0.55	0.67	1			
CAP	13	-0.07	-0.47	-0.11	0.04	-0.00	0.08	0.09	0.25	0.15	0.38	-0.24	-0.37	1		
TERMINALS	14	-0.02	-0.39	-0.26	-0.06	-0.06	-0.35	0.22	0.38	0.22	0.64	-0.27	-0.45	0.21	1	
ATLANTIC	15	-0.07	0.17	0.30	0.00	0.20	0.13	-0.10	-0.28	-0.13	-0.83	0.47	0.29	-0.27	-0.66	1

TABLE 3 : *Estimation results explaining CD*

Specification	OLS (Vol as exogenous variable)			2SLS (Vol as endogenous variable)			System GMM (Vol as endogenous variable)		
	Model A	**Model B**	**Model C**	**Model A**	**Model B**	**Model C**	**Model A**	**Model B**	**Model C**
CONSTANT	18.98*** (1.60)	18.67*** (1.58)	18.45*** (1.52)	19.59*** (1.68)	19.17*** (1.66)	19.05*** (1.60)	19.69*** (1.53)	19.29*** (1.51)	18,99*** (1.54)
RCAPSHARE	3.52* (1.85)	3.24* (1.85)	3.29* (1.77)	5,69** (2.51)	5.18** (2.54)	5.64** (2.44)	5.64** (2.37)	5.02** (2.38)	5.50** (2.30)
UNC	-0.36 (0.97)	-0.37 (0.97)	-0.23 (0.94)	-0.29 (0.98)	-0.32 (0.98)	-0.18 (0.95)	-0.41 (1.00)	-0.50 (0.99)	-0.35 (0.93)
STDEVOIL	-0.24* (0.14)	-0.25* (0.14)	-0.23* (0.13)	-0.24* (0.14)	-0,25* (0.14)	-0.24* (0.14)	-0.22 (0.16)	-0.23 (0.16)	-0.22 (0.15)
D2000	-2.67*** (0.86)	-2.81*** (0.86)	-2.70*** (0.83)	-2.47*** (0.89)	-2.63*** (0.88)	-2.49*** (0.86)	-2.45*** (0.75)	-2.63*** (0.74)	-2.42*** (0.74)
VOL	0.72** (0.29)	0.80*** (0.29)	0.92*** (0.28)	0.05 (0.59)	0.22 (0.59)	0.22 (0.57)	0.08 (0.57)	0.28 (0.56)	0.28 (0.56)
In(BILEXP1)	-2.77*** (0.70)			-2.77*** (0.71)			-2.83*** (0.68)		
In(BILEXP2)		-1.23*** (0.29)			-1.19*** (0.30)			-1.23*** (0.29)	
RENEW			-5.63*** (0.97)			-5.63*** (1.01)			-5.53*** (0.85)
LNGSHARE	1.76 (1.27)	2.41* (1.28)	1.83 (1.23)	1.68 (1.29)	2.32* (1.30)	1.73 (1.25)	1.57 (1.15)	2.19* (1.14)	1.70 (1.18)
COMP	-2.70** (1.30)	-2.35* (1.29)	-2.85** (1.25)	-2.93** (1.33)	-2.54* (1.31)	-3.05** (1.28)	-3.14** (1.37)	-2.75** (1.36)	-3.20** (1.41)
Adjusted R^2	0.234	0.239	0.288	0.214	0.225	0.267			
Centered R^2							0.243	0.255	0.296
N	224	224	224	224	224	224	224	224	224

*** Statistically significant at a 1 %-level ; ** statistically significant at a 5 %-level ; * statistically significant at a 10 %-level. All levels of statistical significance are based on two-tailed test statistics. Corrected standard errors in parentheses.

one of the highest of all exogenous variables it supports the theory's prediction that asset specificity is the strongest determinant of transaction costs.

For **Proposition 1b**, we find that the coefficient of the measure of political instability (UNC) lacks any statistical significance. This type of uncertainty does not appear to be the relevant dimension of uncertainty for our unit of analysis and has no impact on contract duration. Joint ventures of private oil and gas majors with national companies as well as the in many cases very high dependence of exporting countries on revenues from oil and natural gas deliveries may mitigate the hazard of opportunistic behavior of upstream states. The variable indicating price uncertainty (STDEVOIL) shows the expected sign and is statistically significant for the 2SLS models; hence, contract duration appears to decrease with the risk of being bound by an agreement that no longer reflects the actual price level, which determines the profitability of the capital-intensive LNG value chain.

As expected, the variable controlling for the need for flexibility as measured by the start-up date of the contract (D2000) indicates that contract duration decreases over time. Whereas in the first generation LNG market inflexible bilateral long-term supply agreements typically lasted 20 to 30 years, the second generation market is characterized by a considerable expansion of capacities, changing trading conditions due to restructuring processes in downstream markets favoring competition, and trading places gaining in liquidity. Market liquidity promotes the use of flexible trades that help parties benefit from arbitrage potentials in the global market.

Proposition 2a refers to the impact of transaction frequency within the relationship. We found no statistical significance of the coefficient of the annual contracted volume (VOL) indicating the number of transactions (*i.e.*, cargo deliveries) within the trading relationship for the models accounting for the endogeneity of this variable (9). An alternative estimation testing for a non-linear impact of the contracted volume does not change the result. Real-world LNG contracts contain numerous clauses that specify potential adaptations to changing environmental conditions. Because most agreements are confidential, we are unable to account for the impact of provisions such as pricing clauses that would be highly valuable for research purposes.

Our empirical results provide broad support for **Proposition 2b**; the estimation coefficients of all three variables (ln(BILEXP1), ln(BILEXP2), and RENEW) have the expected negative signs and are highly statistically significant. We can confirm that LNG supply contracts decrease in duration as bilateral trading experience between the contracting parties (*i.e.*, historical transaction frequency between the trading partners) increases. This can be explained by a decrease in contracting costs; LNG supplier and buyer gain information about each other's characteristics with every negotiation process, reputational effects may diminish the hazard of opportunistic behavior, and the partners benefit from a body of informal institutions that evolve over repeated bargaining.

The statistically significant control variables also provide interesting findings. As previously noted countries with a greater dependence on imports in the form of LNG (LNGSHARE) tend to negotiate longer-term agreements and forgo some flexibility in favor of supply security. Even in the present economic downturn we expect that new importers with demand growth well above average like China and India will further tighten global supply. Committing to one supplier decreases the risk that the supplier may seek another destination market with more attractive provisions when a shorter-term contract ends.

(9) This shows that ignoring the endogeneity of right-hand-side variables can produce misleading estimation results.

TABLE 4 : Estimation results 1st stage explaining VOL

Specification	2SLS			System GMM		
	Model A	Model B	Model C	Model A	Model B	Model C
CONSTANT	0.38 (0.33)	0.38 (0.33)	0.38 (0.32)	0.38 (0.31)	0.38 (0.31)	0.38 (0.30)
RCAPSHARE	4.04*** (0.39)	4.05*** (0.39)	4.04*** (0.39)	4.04*** (0.41)	4.05*** (0.41)	4.04*** (0.41)
UNC	0.05 (0.20)	0.04 (0.20)	0.02 (0.20)	0.05 (0.17)	0.04 (0.17)	0.02 (0.17)
STDEVOIL	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)
D2000	0.24 (0.18)	0.25 (0.18)	0.24 (0.18)	0.24 (0.19)	0.25 (0.19)	0.24 (0.18)
ln(BILEXP1)	0.11 (0.15)			0.11 (0.13)		
ln(BILEXP2)		0.08 (0.06)			0.08 (0.06)	
RENEW			0.46** (0.21)			0.46 (0.22)
LNGSHARE	-0.09 (0.32)	-0.10 (0.32)	-0.04 (0.32)	-0.09 (0.34)	-0.10 (0.34)	-0.04 (0.34)
COMP	-0.29 (0.32)	-0.29 (0.33)	-0.23 (0.33)	-0.29 (0.29)	-0.29 (0.29)	-0.23 (0.30)
SELFSUFF	0.23 (0.33)	0.23 (0.33)	0.21 (0.33)	0.23 (0.31)	0.23 (0.31)	0.21 (0.32)
CAP	0.03*** (0.004)	0.03*** (0.004)	0.03*** (0.005)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)
TERMINALS	-0.02** (0.01)	-0.03** (0.01)	-0.03** (0.01)	-0.02** (0.01)	-0.03** (0.01)	-0.03** (0.01)
Adjusted R^2	0.466	0.469	0.477			
Centered R^2				0.490	0.493	0.500
N	224	224	224	224	224	224

*** Statistically significant at a 1 %-level ; ** statistically significant at a 5 %-level ; * statistically significant at a 10 %-level. All levels of statistical significance are based on two-tailed test statistics. Corrected standard errors in parentheses.

Furthermore, we find that deliveries to competitive downstream markets (COMP) are realized *via* shorter-term agreements, confirming previous findings of Hirschhausen and Neumann (2008) who analyze a dataset including pipeline as well as LNG contracts. Competition favors diversification of suppliers, supply sources, and supply routes and hence is conducive to supply security ; long-term contracts lose in importance.

Table 3 shows the estimation results of the first-stage regression (Equation 6) which explains annual contracted volume adding a set of instrumental variables. For econometric reasons all system exogenous variables must be included in this regression. The level of self-sufficiency (SELFSUFF) in natural gas supply of the importing country has no major impact on the contracted volume. The higher the nominal import terminal capacity (CAP) the higher will be the contracted volume. There is a negative relationship between the number of import facilities (TERMINALS) in the buying country and the annual contracted volume. This result, for example, reflects the situation in Japan, where numerous (also small scale) terminals near all major demand centers substitute for the nonexistent gas transmission network, whereas countries such as Belgium receive all deliveries *via* a single import facility.

However, theory argues that the level of specific investments is itself a decision variable (Masten, 1995). Therefore, we run an additional regression model explaining in a first step the variable indicating relationship-specific investments in the LNG industry (RCAPSHARE) by the set of all exogenous variables and an additional instrument (ATLANTIC). The predicted values of asset specificity are included into the 2SLS model. Estimation results are listed in Table 5 and reconfirm the above findings. Only the coefficient of the level of specific investments (RCAPSHARE_hat) loses in statistical significance.

VI. — SUMMARY AND CONCLUSIONS

This paper provides an empirical assessment of LNG supply contracts in order to determine optimal contract duration. We derive testable hypotheses from theoretical approaches on contracting and discuss the trade-off between contracting costs due to repeated bilateral bargaining versus the need for flexibility in uncertain environments. Estimation results of a model of simultaneous equations show that the presence of high, dedicated asset specificity in LNG contracts results in longer contract duration, which confirms the predictions of transaction cost economics. We observe, however, that the increasing need for flexibility in today's second generation LNG industry reduces contract duration, as does the presence of a high price uncertainty. Firms experienced in bilateral trading generally are able to negotiate shorter contracts. We also find that countries that rely heavily on LNG imports are often willing to forgo some flexibility in favor of supply security whereas deliveries to competitive downstream markets take place under shorter-term agreements.

We could not fully confirm the theoretically discussed trade-off because not all uncertainty variables produce significant results. Numerous empirical studies investigating the effect of environmental uncertainty on governance choice present non-significant and even ambiguous results (*e.g.*, Crocker and Masten, 1988; Klein *et al.*, 1990, Heide and John, 1990). However, as Klein (1989, p. 256) states: « It appears that uncertainty is too broad a concept and that different facets of it lead to both a desire for flexibility and a motivation to reduce transaction costs ». Klein argues further that the effect depends on the dimension of uncertainty; the author shows that whereas unpredictability should have a negative impact on vertical control, complexity should be positively related to more hierarchical governance structures. We suggest that empirical studies should split external uncertainty into its components, investigate the opposing effects and determine which dimensions of uncertainty are

TABLE 5 : Estimation results RCAPSHARE engodenized using 2SLS (10)

Specification	**1st stage (Dep. var. : VOL)**			**2nd stage (Dep. var. : CD)**		
	Model A	**Model B**	**Model C**	**Model A**	**Model B**	**Model C**
CONSTANT	0.59 (0.80)	0.61 (0.78)	0.57 (0.79)	19.97*** (2.05)	19.52*** (1.98)	19.33*** (1.89)
RCAPSHARE_hat	3.29 (2.53)	3.20 (2.51)	3.33 (2.60)	4.81 (3.02)	4.25 (3.04)	4.88* (2.88)
UNC	0.09 (0.27)	0.08 (0.27)	0.05 (0.27)	-0.23 (1.02)	-0.27 (1.01)	-0.15 (0.98)
STDEVOIL	-0.02 (0.04)	-0.02 (0.04)	-0.02 (0.04)	-0.24 (0.15)	-0.25* (0.14)	-0.24* (0.14)
D2000	0.25 (0.22)	0.27 (0.22)	0.26 (0.22)	-2.44*** (0.92)	-2.62*** (0.90)	-2.48*** (0.88)
ln(BILEXP1)	0.07 (0.23)			-2.89*** (0.78)		
ln(BILEXP2)		0.06 (0.09)			-1.24*** (0.32)	
RENEW			0.44 (0.27)			-5.40*** (1.04)
LNGSHARE	-0.11 (0.39)	-0.11 (0.39)	-0.05 (0.39)	1.48 (1.43)	2.14 (1.41)	1.56 (1.37)
COMP	-0.45 (0.65)	-0.47 (0.64)	-0.38 (0.66)	-2.96** (1.37)	-2.56* (1.34)	-3.06** (1.31)
SELFSUFF	0.50 (0.97)	0.54 (0.99)	0.47 (1.03)			
CAP	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)			
TERMINALS	-0.03* (0.01)	-0.03* (0.01)	-0.03* (0.01)			
Adjusted R^2	0.457	0.211	0.218	0.176	0.195	0.232
N	224	224	224	224	224	224

*** Statistically significant at a 1 %-level ; ** statistically significant at a 5 %-level ; * statistically significant at a 10 %-level. All levels of statistical significance are based on two-tailed test statistics. Corrected standard errors in parentheses.

relevant for the respective transaction. Furthermore, contractual provisions (such as price adaptation clauses) – which unfortunately are confidential and cannot be incorporated in our analysis – are an important measure to react to changing environmental conditions and to decrease the inflexibility of long-term agreements. We note that motivations other than efficiency (*e.g.*, strate-

(10) Estimation results of the model explaining RCAPSHARE using the set of exogenous variables as well as the additional instrument ATLANTIC is available from the author upon request. Using the method of GMM, we could verify the above presented results.

gic reasons, the establishment of a portfolio of activities, or market foreclosure) can also drive company behavior.

Our empirical study can only confirm one of the two complementary predictions of transaction frequency's impact on vertical control. We note the importance of distinguishing between a « within » perspective (*i.e.*, transaction cost economics view) and a « between » perspective (*i.e.*, organizational learning and reputational effects view).

Future empirical work should address several issues. First, alternative theories should be explored to explain company behavior and the choice and structure of governance modes. Aggarwal (2007, p. 485) stresses that « while … different theories have emphasized different factors, it is plausible that in many situations these factors supplement each other rather than being exclusive ». Second, researchers need to identify better proxies of theoretical constructs (transaction costs, asset specificity, uncertainty, etc.) that will improve empirical testing. Third, the historical frequency of transactions between the same partners should also be treated as a decision variable. Finally, although empirical studies should account for simultaneous choice of contract provisions like contract duration or the level of completeness of contracts, we acknowledge the challenges due to very limited data availability.

The structure of international LNG trade is changing both in quantity and quality: natural gas hubs gain liquidity, long-term contracts and short-term agreements co-exist, and the duration of shipping charter contracts is falling significantly. However, LTCs are still the optimal means to secure the amortization of infrastructure investments. No upstream greenfield project has become operational without a significant share of the capacity dedicated to long-term agreements. Nevertheless, a growing share of capacities, especially of expansion projects, is dedicated to seasonal and short-term contracts. Contract renewals often result in shorter contracts with a lower volume than the initial agreements (*e.g.*, contracts between Australian NWS LNG and Japanese customers renewed in 2006).

If the first generation of LNG market companies tended to develop bilateral trading relationships within one of the major regions (North America, Europe-Eurasia-North Africa, or Asia-Pacific), today's market motivates entry along the entire value chain. This allows players to invest in varying export and import positions, as well as in flexible transport capacities that enable arbitrage trades and the realization of swap agreements (11). This new type of flexi-

(11) As reported by World Gas Intelligence, Électricité de France recently signed a swap agreement with the US-based Dow exchanging one cargo slot per month at either Zeebrugge (Belgium) or Montoir (France) for one slot at the Freeport LNG receiving terminal (Texas). This second trans-Atlantic swap agreement in 2008 follows Suez and ConocoPhillips (also involving the Freeport and Zeebrugge terminals).

bility holds the key to ensure supply security; for one of the first discussions of LNG arbitrage see Zhuravleva (2009). This has important implications for governmental policies concerning energy security. For example, policy-makers need to determine whether exceptions to the general rule of competition should be applied both upstream (liquefaction, *e.g.*, ensuring a diversified contract portfolio) and downstream (regasification, *e.g.*, ensuring open access).

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