Changing Contract Structures in the International Liquefied Natural Gas Market – A First Empirical Analysis

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Abstract

This paper provides an empirical assessment of liquefied natural gas (LNG) supply contracts to determine optimal contract duration. We study the trade-off between contracting costs due to repeated bilateral bargaining versus flexibility. Estimation results of a simultaneous equation model show that the presence of high dedicated asset specificity results in longer contracts thus confirming the predictions of transaction cost economics, whereas the need for flexibility reduces contract duration. With increasing bilateral trading experience contract duration decreases. We furthermore observe that countries heavily reliant on natural gas imports via LNG are willing to forgo some flexibility in favor of supply security.

JEL-Codes: D23, L22, L95

Keywords: long-term contract, optimal contract duration, transaction cost economics, contracting costs, liquefied natural gas

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1 Introduction

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

The dynamic factors currently affecting the global market for natural gas are: increasing competition for world reserves in a seller's market, realization of large-scale infrastructure investments (LNG as well as pipelines), new market entrants (countries as well as companies), and alterations in trade structures. The past five to ten years have seen the global LNG industry undergoing rapid maturation (Ruester and Neumann, 2006). Changes in the institutional framework of downstream markets (i.e. Continental Europe and Asian importers such as Japan) 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 added chain for LNG deliveries from Qatar to the UK); 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 between spot markets and full vertical integration. However, the structure of LTCs has also changed: contract duration is decreasing, oil-price indexation is diminishing in importance in favor of gas-to-gas competition, and inflexible clauses (e.g., take-or-pay or destination obligations) have been relaxed or eliminated (IEA, 2004).

Theoretical literature discussing the structure of LTCs can be classified into three main approaches: 1) transaction cost economics, assuming bounded rationality of economic actors as well as asymmetric information, argues that LTCs are a way of minimizing transaction costs in bilateral relationships where asset specific investments occur with complex contracts functioning to overcome the ex-post hold-up problem without integrating vertically (see Williamson, 1975, 1985; Klein et al., 1978); 2) the property rights approach is a theory of incomplete contracts assuming rational agents with symmetric information but non-verifiability of actions by third parties. It emphasizes the impact of ex-post opportunism on ex-ante investment incentives, formalizes the hold-up problem arising from relationship specific investments, and discusses the optimal transfer of residual control rights (see Grossman and Hart, 1986); and 3) incentive theory, assuming rational agents but asymmetric

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

information, formalizes the problems of adverse selection and moral hazard. It discusses optimal contract design to overcome principal-agent problems (see Laffont and Martimort, 2002).

Several empirical studies investigate the interrelation between contract duration and environmental characteristics, most of which are based on a transaction cost framework. 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 if site specific, physical asset specific or dedicated investments occur. Kerkvliet and Shogren (2001), too, confirm transaction cost economics by empirically investigating coal contracts. They find a positive relationship between physically specific investments and contract duration decreases with rising trading and market experience.

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 that are in the process of 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. Neumann and Hirschhausen (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 showing that investments linked to specific infrastructures increase contract duration by an average of four years.

Yoder et al. (2008) add to the discussion of optimal contract duration a model investigating the relationship between contract duration and input investment and show that short-term agreements provide weak incentives for durable investments if the ex-post transfer of assets is difficult. They test derived hypotheses using data on US private grazing contracts. Saussier (2000) tests 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.

This paper provides an empirical assessment of LNG supply contracts. We discuss the determination of the optimal contract length as a trade-off between the minimization of transaction costs from repeated bilateral negotiation versus the inflexibility due to long-term commitments. Building a simultaneous equation model to account for endogeneity of a right-hand side variable, 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 parties) on contract duration. Estimation results 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. When firms have experience in bilateral trading, contract duration decreases. 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.

The paper is organized as follows: Section 2 discusses the theoretical background and derives testable hypotheses; Section 3 introduces the industry-specific context. Section 4 summarizes the dataset and introduces the methodology. We present and interpret estimation results in Section 5 before concluding in Section 6.

2 Theoretical Background

2.1 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 (Gray, 1978; Crocker and Masten, 1988; Klein, 1989; Klein et al. 1990; Heide and John, 1990). On the one hand, 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. On the other hand, contract duration is limited due to uncertainty about the future and the hazard of being bound in an agreement not reflecting market realities (e.g., demand levels, input and output prices, changes in institutional environment, technological innovations); 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: 328).

The optimal level of contract duration τ^* corresponds to a situation where the marginal costs equal the marginal benefits of contracting. 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 of the environment 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 party 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 is a graphic illustration of the optimization problem. An increase in the level of uncertainty (u'' > u) results in an upward shift of the marginal cost curve; an increase in the level of asset specificity (s' > s) results in an upward shift of the marginal benefits curve.

Figure 1: Optimization problem



We can formalize the discussion above by the following optimization problem:

$$\max_{\tau} G(\tau) \quad \text{with} \quad G(\tau) = B(\tau) - C(\tau) \tag{1}$$

with G being the net gains which equal the difference between the benefits of contracting B and the costs of contracting C. The first order condition yields

$$G'(\tau) = MB(\tau) - MC(\tau) = 0$$

$$MB(\tau^*) = MC(\tau^*)$$
(2)

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

$$MB(\tau^*) = MB(\tau, s, \nu) = \alpha_0 + \alpha_1 \tau + \alpha_2 s + \nu$$

$$MC(\tau^*) = MC(\tau, u, \omega) = \beta_0 + \beta_1 \tau + \beta_2 u + \omega$$
(3)

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 (3) into (2) and rearranging yields the reduced form

$$\tau^* = \gamma_0 + \gamma_1 s - \gamma_2 u + \varepsilon$$
(4)
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 side of the equation and contracting attributes on the right. From the discussion above we derive the following propositions:

<u>Proposition 1a:</u> 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 supplier and buyer.

<u>Proposition 1b:</u> Higher environmental uncertainty should reduce contract duration to minimize the inflexibility of being bound in a long-term commitment not reflecting market realities.

2.2 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 – hence increasing the incentive to organize the transaction under stronger internal control. An alternative, complementary explanation for a high frequency that results 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 Roberts, 1992; Langlois, 1992), all of which reduce the need for formal mechanisms to enforce bilateral agreements. 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 that reputational considerations have an effect on both the parties' surplus and the optimal choice of asset ownership. These two perspectives on transaction frequency complement one another. We expand the above developed model (4) including two frequency measures: fw indicating the frequency of the transaction within the relationship and fb indicating the frequency of transactions between the trading parties expecting a positive (respectively negative) relationship with contract duration:

$$\tau^* = \gamma_0 + \gamma_1 s - \gamma_2 u + \gamma_3 f w - \gamma_4 f b + \varepsilon$$
⁽⁵⁾

We therefore derive the following propositions:

<u>Proposition 2a</u>: 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.

<u>Proposition 2b:</u> Contract duration should decrease with the frequency of transactions between the same trading parties due to learning and reputational effects.

3 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 (e.g., Japan, South Korea, and Taiwan) lacking large domestic energy supplies and pipeline sources historically relied upon LNG imports.

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 lower average transport costs; break-even of pipeline and LNG transport is now achieved at about 3,000 km (Jensen 2004). Investment costs for the entire value added chain lie in the range of 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 Korea, India, and China among others. Importers compete for supplies in today's seller's market. The Middle East accounts for more than 40% of worldwide proven natural gas reserves and is expected to become the largest regional 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 have provided perspectives on the emerging corporate strategies employed. Cornot-Gandolphe (2005) and Iniss (2004) indicate that long-term contracts are increasingly accompanied by flexible short-term agreements.³ Shorter contracts support arbitrage trade with deliveries dedicated to the highest value market.

Average contract duration in the natural gas industry has shortened significantly; whereas traditionally 25 years was common, newer agreements typically range between 8 to 15 years for contracts supplying Europe 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 of one cargo up to several months to meet seasonal variations. Hence, our contribution to the literature is a deeper analysis of the determinants of contract duration of 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.).

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.

4 Data and Methodology

4.1 Data

The global dataset is compiled from publicly available information (e.g., periodical reports, newsletters, and industry journals). It includes contracting partners, annual and total contracted volumes, year of contract signature, start date of deliveries and contract duration. Both, 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 a LTC, i.e. a share of the capacity is employed in more flexible trade (e.g., Oman LNG; Woodside's Pluto LNG in Australia).

currently in place and contracts that already have been terminated covering the period from industry advent in the mid-1960s until today are incorporated (about 80% of all recently existing long-term LNG supply contracts).⁴



Figure 2: Contract duration and start of deliveries of LTCs included in our sample

Omitting observations with missing data as well as contracts with a contract duration of less than five years (since these have the character of short-term agreements in the LNG industry), the sample consists of 216 LNG supply contracts, of which 79 correspond to Atlantic Basin trade and 137 to Asia-Pacific deliveries. Figure 2 illustrates the contract duration of all LNG supply contracts included in our estimation sample. Contract duration of these agreements typically is in the range of 15 to 35 years in the early decades of the industry, but in the last decade there is an increase in the number of agreements starting delivery prior to the year 2000 is 20.5 years in our sample; for contracts starting delivery from 2000 on it is 17.2 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.

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.

⁵ Differentiating between importing regions, average contract duration in Continental Europe has been 21 years (16.4 years), in the more competitive natural gas markets of North America and the UK 19.2 years (18.5 years), and in Asia 20.5 years (18.2 years) before and from the year 2000 on respectively based on our dataset.

4.2 Explanatory variables

Asset specificity. Asset specificity refers to the degree to which an LNG import terminal is not redeployable. The transformation of the natural gas market to a seller's market accompanied by restructuring and liberalization of downstream natural gas (and electricity) markets has resulted 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; further, competitive downstream markets provide easy access to numerous buyers. To quantify the level of idiosyncrasy (i.e., dedicated asset specificity) we use the ratio to which the contract exploits the nominal capacity of the import terminal (<u>RCAPSHARE</u>) as a proxy.⁶

Uncertainty. Klein (1989) distinguishes between complexity and unpredictable components; Williamson (1985: 57) states that "disturbances... are not all of a kind. Different origins are usefully distinguished." This paper focuses on external uncertainty components measuring environmental dynamism (i.e., price uncertainty, political instability in the exporting country, and general environmental uncertainty). We employ the annualized standard deviation of West Texas Intermediate crude oil spot prices (STDEVOIL) in the year before contract signature since oil prices traditionally influence natural gas prices via oil-linkage in pricing formulas.⁷ We add a second variable for political uncertainty in the exporting country (UNCERT) based on POLCON (Henisz, 2000): this index measures the degree of constraints on policy change in a country averaged for five-year periods since $1960.^{8}$ We then add a third variable to account for a firm's need for flexibility. Whereas the early industry relied on inflexible, well predictable, bilateral buyer-seller relations, the industry today is characterized by significant 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 in importance, numerous companies invest in a portfolio of export and import positions to be able to benefit from arbitrage potentials. Therefore flexibility is of prime importance. We use a dummy variable indicating LNG supply contracts that came into operation after 1999 (D2000) expecting a negative relationship between D2000 and CD.

⁶ Transaction cost economics distinguishes between physical asset, site, dedicated, human, intangible and temporal specificity. 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 oil company or consortium. Physical, human, intangible and temporal specificity for our unit of analysis are less relevant.

⁷ Even though oil-linkage is substituted step by step in favor to gas indexes that reflect gas-to-gas competition, this variable is an adequate measure of price uncertainty.

⁸ 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 UNCERT 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.

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 (<u>VOL</u>) assuming that contracts are fulfilled according to their specifications. Since the standard sizes of LNG vessels typically range from 130,000 to 145,000 m³, the annual contracted volume provides a good indicator for the frequency of shipments within the contract.

Transaction frequency between trading parties. We use the variable <u>BILEXP</u> to measure bilateral trading experience between the two parties assuming that repeated negotiation of LNG supply contracts reduces contracting costs. Theory argues that transaction costs diminish due to learning processes; contracting parties gain information about the other one's behavior. We define the variable as a count index indicating the cumulative number of LNG trade relationships between supplier and buyer. Thus, if the parties negotiate a contract for the first time BILEXP will be 1; if we observe a second contract between the same parties BILEXP will be 2, and so on.

Control variable. We include the buyer country's LNG share in total imports (<u>LNGSHARE</u>) 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, others like South Korea or Japan rely heavily upon LNG imports. The higher the share of LNG in total imports the higher should be the duration of supply contracts.

Instruments. To account for endogeneity of a right-hand side variable (i.e., contracted volume) and conduct system estimation of simultaneous equations we need to include instrumental variables (for details see Section 4.3). We use the nominal capacity of the import terminal (<u>CAP</u>), the level of self-sufficiency of the importing country (ratio of domestic natural gas production over total consumption, <u>SELFSUFF</u>), and the number of import terminals in the respective country (<u>TERMINALS</u>). For a survey of all exogenous variables see Table 1.

Table 2 provides summary statistics of the endogenous, exogenous, and instrumental variables. Contract duration ranges between 5 and 36 years with an overall average of 19 years. About half of the contracts of our dataset (52%) started delivery from 2000 on, mirroring the expanding international LNG trade during the last decade. The contracts account for very small shares of the terminal capacities (0.2%; deliveries from Australia to Japanese customers) as well as for a share of up to 100% (deliveries from Qatar to India). The political uncertainty index of the exporting countries ranges between 0.15 and 1; the annualized standard deviation of the WTI crude oil spot price in the year before contract signature varies strongly between nearly 0 and 0.8 for recently concluded contracts. Annual contracted volume is between 0.03 bcm/a (deliveries from Australia to Japan) and 8.1 bcm/a (planned deliveries from Indonesia to the US). The negotiating parties in most cases bargained for the first time, however bilateral experience for single players shows values of up to 9 (Gaz de France and Algerian Sonatrach). The dataset involves both highly self-sufficient (e.g., US) and LNG import-dependent (e.g., Japan) countries. The number of import terminals per country is between 1 (e.g., Belgium, Greece, Turkey) and 28 (Japan).

Table 1: Exogenous variables

Characteristic	Proxy	Denotation	Exp. Sign					
Propositions 1a and 1b								
Dedicated asset specificity	Ratio to which the contract exploits the nominal capacity of the import terminal [%]	RCAPSHARE	+					
External uncertainty and need for flexibility	Political instability in the supplying country	UNCERT	-					
	Standard deviation of WTI crude oil spot price in the year before contract signature	STDEVOIL	-					
	Dummy [D=1 for start-up after 1999]	D2000	-					
Propositions 2a and 2b								
Within frequency	Vithin frequency Annual contracted volume [bcm/a]							
Between frequency	BILEXP	-						
Control variable								
Dependence on LNG	LNG share in total natural gas imports [%]	LNGSHARE	+					
Instruments								
Import terminal capacity	Nominal capacity of the import terminal [bcm/a]	CAP						
Self-sufficiencyDomestic production/total consumption [%]		SELFSUFF						
Number of import terminals	TERMINALS							

Table 2: Summary statistics

	Unit	Mean	Min	Max	Std. Dev.	Ν
CD	a	19.042	5	36	5.474	216
RCAPSHARE	%	0.222	0.20	0.99	0.244	216
UNCERT		0.647	0.15	1	0.381	216
STDEVOIL		0.206	0.1	0.811	0.149	216
D2000	dummy	0.519	0	1	0.501	216
VOL	bcm/a	1.873	0.03	8.1	1.649	216
BILEXP		1.676	1	9	1.234	216
LNGSHARE	%	0.743	0.03	1	0.371	216
CAP	bcm/a	17.204	0.21	75	17.127	216
SELFSUFF	%	0.166	0	1	0.339	216
TERMINALS		15.893	1	28	12.040	216

4.3 Methodology

To test our propositions, we define the following estimation model with contract duration as the endogenous variable.⁹

$$CD_{i} = \phi_{0} + \phi_{1}RCAPSHARE_{i} + \phi_{2}UNCERT_{i} + \phi_{3}STDEVOIL_{i} + \phi_{4}VOL_{i} + \phi_{5}LOG(BILEXP_{i}) + \phi_{6}LNGSHARE_{i} + \phi_{7}D2000_{i} + \varsigma_{i}$$
(6)

where *i* indexes contracts and the error term ζ_i is assumed to be i.i.d. However, contract duration and contracted volume are determined simultaneously when an LNG seller and buyer agree to a supply arrangement. Therefore, we estimate the model applying system two-stage least squares (2SLS) and verify estimation results using the system generalized method of moments (GMM) procedure¹⁰ with

$$VOL_{i} = \theta_{0} + \theta_{1}CD_{i} + \theta_{2}SELFSUFF_{i} + \theta_{3}CAP_{i} + \theta_{4}TERMINALS_{i} + \xi_{i}$$
(7)

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

5 Estimation Results and Interpretation

Table 3 presents estimation results of the simultaneous equation system accounting for endogeneity. System 2SLS and system GMM lead to very similar results. Propositions 1a, 1b in part 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 R² for the equation explaining contract duration is 0.19 and 0.18 respectively.

Transaction cost predictions of <u>Proposition 1a</u> are confirmed for the variable indicating the ratio to which the contract exploits the nominal capacity of the import terminal (RCAPSHARE). The more important the respective contract to the import terminal and therefore the higher dedicated asset specificity, the longer the contract's duration in order to mitigate the hazard of ex-post hold-up. Buyers relying strongly on one supplier prefer longer-term contracts. In addition, since the level of the coefficient is one of the highest of all exogenous variables it supports the theory's prediction that asset specificity is the strongest determinant of transaction costs.

⁹ Based on a first regression analysis including BILEXP in linear as well as quadratic form we find a nonlinear relationship between BILEXP and CD; therefore we include the logged value into the estimation model.

¹⁰ GMM is a robust estimator; no information of 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.

For <u>Proposition 1b</u>, we find that the coefficients of the measures of political instability (UNCERT) and of the variable indicating price uncertainty (STDEVOIL) both lack statistical significance. 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). Klein (1989) 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 (low statistical significance), complexity should have a positive impact (high statistical significance).

The variable controlling for the need for flexibility as measured by the start-up date of the contract (D2000) indicates as expected that contract duration has decreased over time. Whereas in the "first generation" LNG market inflexible bilateral long-term supply agreements typically lasted 20 to 35 years, the "second generation" LNG market is characterized by a considerable expansion of capacities (e.g., worldwide regasification capacities doubled from 2000 on), 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 gas market.

<u>Proposition 2a</u> 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. Real-world LNG contracts contain numerous clauses that specify potential adaptations to changing environmental conditions. Unfortunately for research purposes most agreements are confidential, so we are not able to account for the impact of provisions such as pricing clauses that are valuable to empirical analysis (see Saussier and Yvrande-Billon, 2007).

Our empirical results provide broad support for <u>Proposition 2b</u> – the estimation coefficient of LOG(BILEXP) has the expected negative sign and is highly statistically significant. We can confirm that LNG supply contracts decrease in contract duration as bilateral trading experience between the contracting parties (i.e. transaction frequency between the trading partners) increases. This can be explained by a decrease in contracting costs; LNG supplier and buyer gain information about the other party'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 variable also provides an interesting finding. As previously noted countries with a greater dependence on natural gas 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 out another destination market with more attractive provisions when a shorter-term contract ends.

The second equation in the econometric system explains annual contracted volume employing a set of instrumental variables. As contract duration (CD) increases so does annual volume. This mirrors the fact that LTCs are still the means to secure the amortization of infrastructure investments. No upstream green-field project has come on stream without a significant share of the capacity dedicated to long-term agreements. However, 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). The level of self-sufficiency (SELFSUFF) in natural gas supply of the importing country has a positive impact on the contracted volume. This result is somewhat surprising since we expect to see the opposite. The higher the nominal import terminal capacity (CAP), the higher will be the contracted volume as expected. Finally, there is a negative relationship between the number of import facilities (TERMINALS) in the buying country and the annual contracted volume. This result perfectly reflects the situation in Japan, where numerous (also small scale) terminals near all major demand centers substitute for the nonexistent gas transmission network, while other countries such as Belgium receive all deliveries via a single import facility.

Specification		System 2	2SLS	System GMM	
		Parameter	Corrected standard errors	Parameter	Corrected standard errors
CD = dep. var.	CONSTANT	17.905 ***	1.463	15.423 ***	1.305
	RCAPSHARE	3.998*	2.463	4.117 **	2.205
	UNCERT	0.579	0.945	0.916	0.859
	STDEVOIL	-1.178	2.427	-0.200	2.139
	D2000	-2.534 ***	0.720	-1.933 ***	0.629
	VOL	0.201	0.533	0.458	0.467
	LOG(BILEXP)	-2.723 ***	0.673	-2.421 ***	0.627
	LNGSHARE	2.701 ***	1.034	4.264 ***	1.020
	Adjusted R ²	0.185		0.177	
	p-value F-stat.	0.000		0.000	
	Ν	216		216	
VOL = dep. var.	CONSTANT	-0.873	0.861	-0.807	0.763
	CD	0.149 ***	0.044	0.144 ***	0.038
	SELFSUFF	1.103 ***	0.363	1.066 ***	0.358
	CAP	0.021 ***	0.007	0.013 ***	0.008
	TERMINALS	-0.040 ***	0.010	-0.041 ***	0.009
	Adjusted R ²	0.103		0.091	
	p-value F-stat.	0.000		0.000	
	Ν	216		216	

Table 3: Estimation results

*** 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; except for the main dependent variable of Proposition 1a (RCAPSHARE) where we employ a one-tailed test statistic.

6 Summary and Conclusions

This paper provides an empirical assessment of LNG supply contracts in order to determine optimal 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. Estimation results of a model of simultaneous equations show that the presence of high dedicated asset specificity in LNG contracts results in a 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. 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.

We could not fully confirm the theoretically discussed trade-off because the uncertainty variable produces ambiguous results. However, as Klein (1989: 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." Since numerous empirical studies investigating the impact of uncertainty on organizational choice have also found mixed results, we suggest that such studies should split external uncertainty into its components and investigate the opposing effects. We note that motivations other than efficiency (e.g., strategic 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. One has to distinguish 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) 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.) in order to improve empirical testing. Third, although empirical studies should account for simultaneous choice of contract provisions like contract duration or the level of completeness of contracts (Saussier, 2000), 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, too. If the "first generation" LNG market companies tended to develop bilateral trading relationships within one of the major regions (North America, Europe-Eurasia, or Asia-Pacific), the "second generation" LNG market motivates market entry along the entire value chain. This allows players to invest in varying export and import positions, as well as flexible transport capacities that enable arbitrage trades and the realization of swap agreements.¹¹ It also has important implications for governmental policies concerning energy supply 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).

¹¹ As reported by World Gas Intelligence, Électricité de France recently signed a swap agreement with the USbased 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).

7 References

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