Project No 213744

SECURE
Security of Energy Considering its Uncertainty, Risk and Economic implications

SP1 – Cooperation
Collaborative project
Small or medium-scale focused research project

DELIVERABLE No 5.2.5

Vertical Integration Index and Market Structure – Natural Gas
Vertical Integration in Liquefied Natural Gas

Due date of deliverable: End September 2009
Actual submission date: September 2010

Start date of project: 1/1/2008 Duration: 36 months

Organisation name of lead contractor for this deliverable: Chair of Energy Economics and Public Sector Management, Dresden University of Technology, (TUD)

Revision:

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services	

Vertical Integration Index and Market Structure. Natural Gas

Vertical Integration in Liquefied Natural Gas

Chair of Energy Economics and Public Sector Management, Dresden University of Technology (TUD)

Table of Contents

1. Introduction 2

2. Vertical Structures in the LNG Industry 4

2.1 The changing role of long-term contracts 4
2.2 Recent trends towards vertical and horizontal integration 7

3. Empirical Evidence Based on Transaction Cost Economics 11

3.1 Theoretical background 11
3.2 Empirical evidence 12

4. References 16

1. Introduction

Vertical integration along energy value chains is a topic intensively discussed from both an economic and (geo-) political perspective, and thus highly relevant for energy security. The ongoing liberalization of European natural gas and electricity markets focused on an unbundling of transmission infrastructures and restrictions in long-term contracting in order to support competitive market patterns and the development of a functioning internal market. Incumbents as well as new entrants responded to energy political changes by adapting their corporate strategies, including vertical and horizontal structures, too. Amongst others, convergence between natural gas and electricity markets (i.e. vertical integration along the extended value chain including natural gas supply and power production) is an increasing post-restructuring phenomenon.

It is difficult, if not impossible, to study the vertical integration in the natural gas sector at such a level of detail that a vertical integration index could be constructed. Indeed, the data limitations are substantial, both on the European and on the global level. They do not allow to define precisely some of the critical variables (e.g. ownership of ships, joint ownership of pipelines) that would assure the uniqueness of such an index. However, we have been able to carry out an extensive literature survey on the topic of vertical integration and we have studied the phenomenon of vertical integration in the liquefied natural gas (LNG) value chain.

Liquefied natural gas plays an increasing role in the natural gas supplies of many European countries, with many new-built LNG import (regasification) terminals in the last decade. This is a truly global market, where the European importers are competing with American and especially Asian importers. The players in the LNG value chain are global, multi-national companies and it is essential to understand their supply and integration strategies in order to understand the security of European supplies with LNG.

Whereas vertical structures in the natural gas industry within the European Union are mainly determined based on regulations, contracting patterns with external suppliers are predominantly determined by geopolitical considerations of exporting and importing countries as well as corporate-specific strategic considerations. Thereby, the increasing dynamics of the liquefied natural gas (LNG) market are of central interest and have an impact on regional natural gas markets which increasingly become linked.

The past decade has seen the global market for LNG undergoing substantial developments. Driven by growing natural gas demand and declining investment costs for LNG export and import facilities until the mid-2000s, large-scale infrastructure investments have been realized with a doubling of capacities along the whole value chain. New players, countries as well as companies, entered the market. LNG suppliers increasingly follow a strategy of forward integration from the upstream to the downstream sector. Concluding a sales-and-purchase agreement with the own marketing affiliate and investing at the same time in LNG import capacities, leads to the players controlling successive stages of the value chain. Some companies invest in an entire portfolio of LNG export, shipping, and import positions, enabling them to conduct flexible trades and to benefit from regional price differences. Furthermore, traditional natural gas distributors started to participate in LNG export ventures and also electricity companies entered the market and integrate backward from the downstream to the upstream sector.

In contrast, some new entrants invested in non-integrated LNG import terminals operating them as so called tolling facilities, selling the service of unloading, regasification, and storage to third parties, or speculating for short-term deliveries.

This deliverable discusses vertical structures in the global LNG market and summarizes empirical evidence on vertical integration along the LNG value chain based on transaction cost economics.

2. Vertical Structures in the LNG Industry

The development of the global LNG market from an infant towards a mature industry has been accompanied by far-reaching dynamics in vertical structures within the industry. We focus on the changing role of traditional long-term contracts and the increasing relevance of short-term and spot trade. A number of oil and gas majors follows a strategy of vertical and horizontal integration investing in a portfolio of export, shipping, and import capacities at the same time that other companies choose a strategy of non-integration operating LNG terminals as 'tolling facilities'.

2.1 The changing role of long-term contracts

Investments in LNG infrastructure, especially in upstream exploration, production, and liquefaction, are very capital-intensive. Therefore, financing traditionally required the conclusion of long-term sales and purchase contracts before the construction process was initiated (Jensen, 2009a). Sellers typically have been state-owned oil and gas majors (e.g., Algerian Sonatrach) and for a minor share joint ventures of private companies (i.e., US' Philipps and Marathon) or of private and state companies (e.g., Brunei Coldgas, a partnership between the state of Brunei, Shell, and Mitsubishi). Buyers typically have been downstream state-controlled utilities (e.g., Gaz de France, Japanese Tokyo Gas).

The traditional contract was a rigid take-or-pay contract in which the buyer accepted to take-off a certain minimum level in the range of 90% of the nominal contracted quantities. The seller in turn accepted a price escalator related to some measure of competing energy prices. Hence, the buyer took the volume risk whereas the price risk was transferred to the seller. Restrictions in destination limited arbitrage trades.

Within the three importing regions, alternative contracting patterns and pricing structures established. Prices for LNG thereby are set either by price competition with domestic gas (mainly US, UK) or by the operation of pricing formulas. When the first LNG contracts were negotiated with Japanese buyers in the 1960s, Japanese power generation was heavily dependent on fuel oil. Pricing clauses therefore tied the price escalation to the Japanese Customs Clearing price. This pricing scheme later was adopted for other Asian contracts, too. In the mid-1990s, the oil-linkage of LNG prices in Asian contracts was softened. So-called 'S-curve' formulas guarantee the interest of

the seller if the price of the benchmark crude oil index drops below a certain threshold and protects the buyer from oil prices rising above a certain ceiling. Asian importers traditionally were willing to pay a price premium of about 1 USD/MBTU as compared to LNG buyers in Europe and North America reflecting their concerns about supply security. Continental European pricing structures were effectively originated by the Netherlands' pricing policies for domestic natural gas produced from the Groningen field since 1962. The natural gas price was indexed to light and heavy fuel oil. This pattern later was also adopted for export contracts. More recent (liquefied) natural gas contracts include also prices of other relevant energy sources such as coal, natural gas or electricity. The improvement of gas-to-gas competition and increasing liquidity in natural gas hubs should support the establishment of gas market indicators. In contrast, North America and the UK today are characterized by a functioning gas-to-gas competition with long- and mid-term contracts being to a large extent tied to gas market indicators.

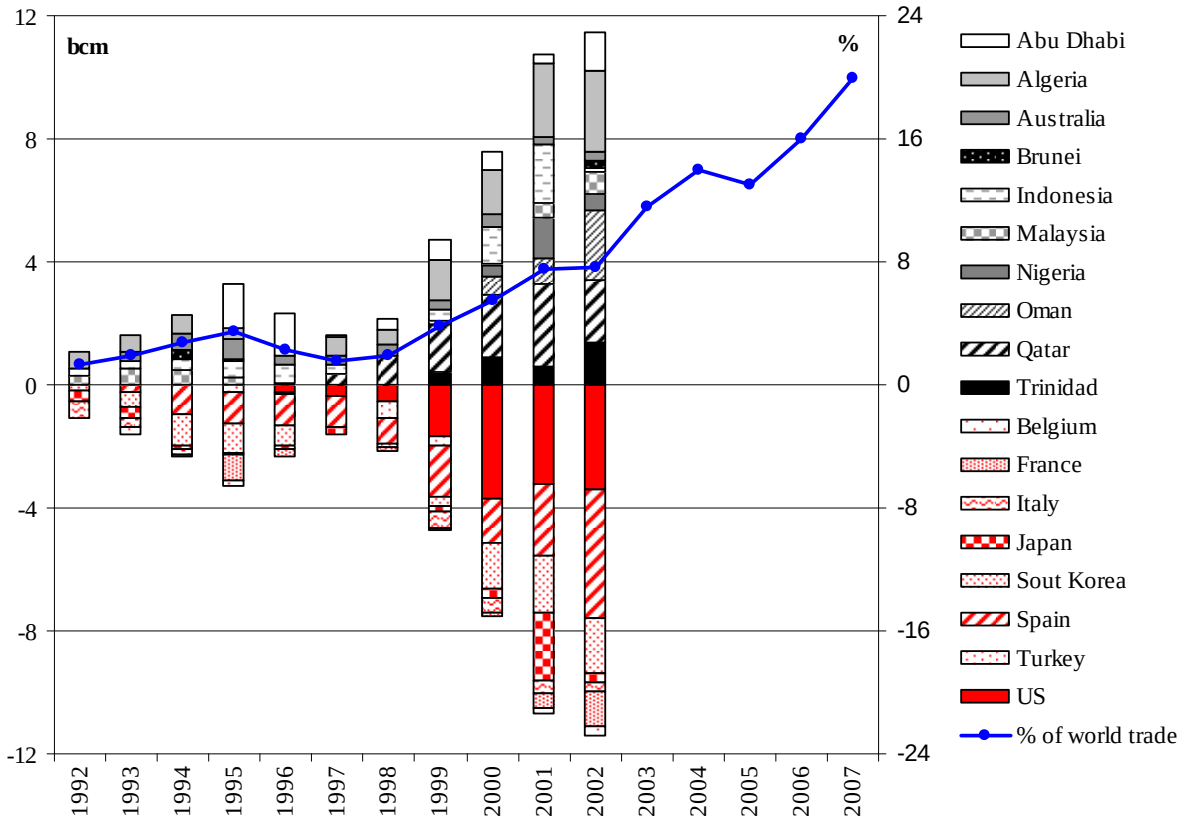
As the LNG industry has expanded during the past decade, terms of long-term supply contracts started to change and trade became more flexible. Average contract duration as well as contracted volumes are decreasing in both Atlantic and Pacific Basin markets (see e.g., Hirschhausen and Neumann, 2008; Ruester, 2009a). Destination clauses are eliminated; take-or-pay requirements are relaxed and options for additional cargoes are included in recent contracts, e.g., in a recent contract between Korea Gas Corporation and Qatar's Rasgas venture. Whereas deliveries in the early years of the industry typically have been ex-ship sales, free-on-board agreements are becoming more common (Eng, 2006; Nissen, 2007). For f.o.b. contracts, the buyer takes ownership of the cargo once it is loaded and has complete flexibility over a potential redirection or resale.

Contract flexibility has also been a major target of buyers when renegotiating existing contracts. It is also becoming common practice to divert contractually committed LNG volumes to third markets given a mutual agreement of both seller and buyer. This increased contract flexibility is supportive to supply security since it permits adaptations to short-term changes in the supply-demand balance. The netback value will determine the most attractive market in those cases where LNG shippers are free in the choice of destination.

Long-term supply contracts allowing the financing of new infrastructures are increasingly accompanied by short-term agreements (less than 3 years) and spot transactions. The short-term market established not before the 1990s with the first arbitrage trades and swap agreements appearing in the early 2000s. EdF (holding 3.3 mtpa at Zeebrugge and 0.7 mtpa at Montoir) has signed a swap agreement with the US-based Dow (3.75 mtpa at Freeport) offering each party a slot of 1 bcm per month of import capacity at the other company's import terminals. The additional margin is shared among EdF, Dow and the supplying company. A similar trans-Atlantic swap agreement involves Suez and ConocoPhilipps. Major short-term and spot volumes today are supplied by Qatar, Algeria, and Oman; main buyers have been the US, Spain and South Korea (see

Figure **1**).

Figure 1: Development of short-term and spot trade



Source: Own depiction based on data from EIA (2003), Cornot-Gandolphe (2005), Jensen (2009b)

For the near-term future, the outlook for spot LNG trade is quite modest and will critically depend on how quickly the global economy recovers from the current recession. Many buyers that have been active in spot- and short-term trade currently can meet their gas requirements by their long-term contracts and some even have to demand downward adjustments in volume flexibility due to weak consumption levels. For the longer term, the outlook is more optimistic. LNG exporters increasingly dispose of uncommitted liquefaction capacities. The overhang in regasification capacities facilitates downstream market access for non-incumbents and the increasing liquidity of European trading hubs enhances price transparency.

2.2 Recent trends towards vertical and horizontal integration

Joint ventures always have been a common form of organization within the LNG industry for two main reasons. First, the large investment costs associated with upstream exploration, production and liquefaction ventures makes it difficult for one single company to develop and finance the project on its own. Joint ventures are set up in order to share the risks and financial burden. Partnerships between private oil and gas companies have formed: e.g., for Alaska LNG (ConocoPhillips and Marathon) or for the North West Shelf Venture in Australia (BHP Billiton, BP, Chevron, Mitsubishi/Mitsui, Shell, and Woodside Energy). Second, a joint venture with the incumbent NOC is likely (e.g., Abu Dhabi, Egypt, Indonesia, Nigeria, Russia or Qatar). On the one hand, NOCs seek to retain control over natural gas reserves; on the other hand, private majors contribute to the partnership technological knowledge and marketing channels. In summary, 15% of the existing nominal liquefaction capacities are owned and operated by joint ventures between private majors, the majority of 76% is controlled by partnerships between NOCs and private partners, and the remaining 9% of the capacities are operated by NOCs without any third party (i.e., Algeria, Libya).

Forward integration from the upstream to the downstream sector is a governance form which has become characteristic for the industry with players controlling capacities along successive stages of the value chain. Upstream producers aim to benefit from downstream margins. One recent phenomenon is the increasing employment of self-contracting. Thereby, the seller concludes for a sales-and-purchase agreement with its own marketing affiliate as has been realized at Qatar's Qatargas and Rasgas liquefaction

projects (Exxon Mobil, Qatar Petroleum, and Total), in Trinidad/Tobago (BP, Repsol, and BG), or Norway (Statoil and Gaz de France). In Nigeria, the first three trains of the Bonny Island venture were dedicated to traditional long-term take-or-pay contracts concluded between the venture and European buyers. For trains 4 and 5 in contrast, Shell and Total (holding equity shares in the liquefaction plant) self-contracted certain volumes. In total, eleven companies have self-contracted for about 1,660 bcm of LNG over the period from 2009 to 2025 (IEA, 2009).

In one version of this commercial business model, the LNG export project is operated as a tolling facility selling the services of liquefaction, storage, and loading to the LNG merchant and natural gas producers rather than the venture become the sellers of natural gas. This structure has been adopted for example in Egypt where the BG Group and BP act as merchant traders at the Idku plant and the Spanish Union Fenosa at the Damietta facility. Alternatively, the venture's project partners buy the LNG from the project.

The unbundling of transportation assets and services from rigid export-import project relationships is a major precondition for flexible trade and the control of non-committed shipping capacities has become of strategic value in today's LNG market. Private players have invested in a significant number of vessels during the last decade: Shell controls 30 carriers through joint ventures and direct ownership. Exxon Mobil and Qatar Petroleum have a fleet of 27 ships. The BG Group owns eight vessels and recently ordered another four ships. Several other companies entered the midstream shipping stage during the 2000s (e.g., BP, Gaz de France, and Osaka Gas). The number of uncommitted ships has increased from approximately zero before 2000 to 49 in 2009 (of a total of 337 ships representing 14% of total shipping capacity).

Self-contracting accompanied with investments in a portfolio of upstream and downstream positions and uncommitted ships enables the players to decide where to send LNG cargoes on a shorter-term basis and to take advantage of favorable price conditions. Three cases demonstrate the successful employment of this strategy: Shell disposes of LNG export positions in Australia, Brunei, Malaysia, Nigeria, Oman, and Russia at the same time that the company holds capacity rights at import terminals in India and Mexico. It will continue its expansion within the industry and participate in projects proposed for France, Italy, and Brazil. Similarly, Total has built up a portfolio of export positions in all three exporting regions and import positions in India, Mexico,

and France. Exxon Mobil and Qatar Petroleum entered a partnership in the late 1990s. In order to mitigate supply costs given the long distance from the Middle East to consuming centers, they constructed the largest liquefaction facilities (7.8 mtpa trains) and ordered the largest vessels (>210,000 m^3) ever, thus realizing substantial economies of scale. At the same time, the partners secured capacity rights at import terminals on both sides of the Atlantic (South Hook in the UK, Rovigo in Italy and Golden Pass in the US).

Backward integration from the downstream to the upstream sector is observed, too. Traditional natural gas distributors increasingly participate in LNG export ventures, motivated mainly by supply security considerations: Gaz de France holds shares in Egypt's Idku project and Norway's Snovhit LNG; Union Fenosa participates in Oman's expansion train; and Tokyo Gas in Australia's Darwin project. Also electricity companies, forming part of the extended value chain including natural gas-fired power production, enter the stage. Whereas Spain's first LNG terminals were operated by Enagas, traditional electricity companies (Union Fenosa, Endesa, and Iberdrola) are now the dominant investors. AES Corporation, the operator of a 319 MW gas-fired power plant in the Dominican Republic also owns and operates the country's LNG import terminal. Electricité de France proposed a regasification facility in the Netherlands. Some Japanese power producers even integrate further upstream: Tokyo Electric Power holds a share in Australia's Darwin project and Kansai Electric will participate in the Pluto venture.

In contrast to these integrated players, there are also some new entrants into downstream LNG markets which follow a strategy of non-integration: With the upcoming enthusiasm for LNG needs within North America in the early 2000s, Cheniere Energy entered the market and applied for the construction of four onshore LNG import facilities at the Gulf coast which should be operated as tolling facilities. The Freeport LNG and Sabine Pass projects were commissioned in 2008. However, the US' supply-demand balance altered throughout the last years. With the development of substantial unconventional resources, increased domestic production is outstripping higher cost LNG supplies. Thus, the two terminals suffer from low utilization rates. Plans to build the additional facilities are dormant at the moment and it is unlikely that these projects will be realized in the next decade. In fact, recent developments have resulted in

liquidity problems for the company and Cheniere had to lay off more than half of its 360 employees in April 2009.

Another entrant is Excelerate Energy, founded in 1999. In 2008, the German RWE acquired a 50% stake in the company. Excelerate employs an innovative technology of offshore, onboard regasification. Five import facilities have been already been built with the Gulf Gateway (start-up 2005) and Northeast Gateway (2008) in the US, Teesside GasPort in the UK (2007), Bahía Blanca GasPort in Argentina and Mina Al-Ahmadi GasPort in Kuwait (both 2008). An additional facility is proposed for Germany offshore Wilhelmshaven. However, industry experts report that only minor deliveries took place up to today through these facilities. The non-integrated players still have to prove to be successful in an industry, which for a long time has been a sellers' market without major uncommitted export capacities, and in which also in the longer-term future, once the economic crisis is overcome, importers are expected to continue to compete for global supplies.

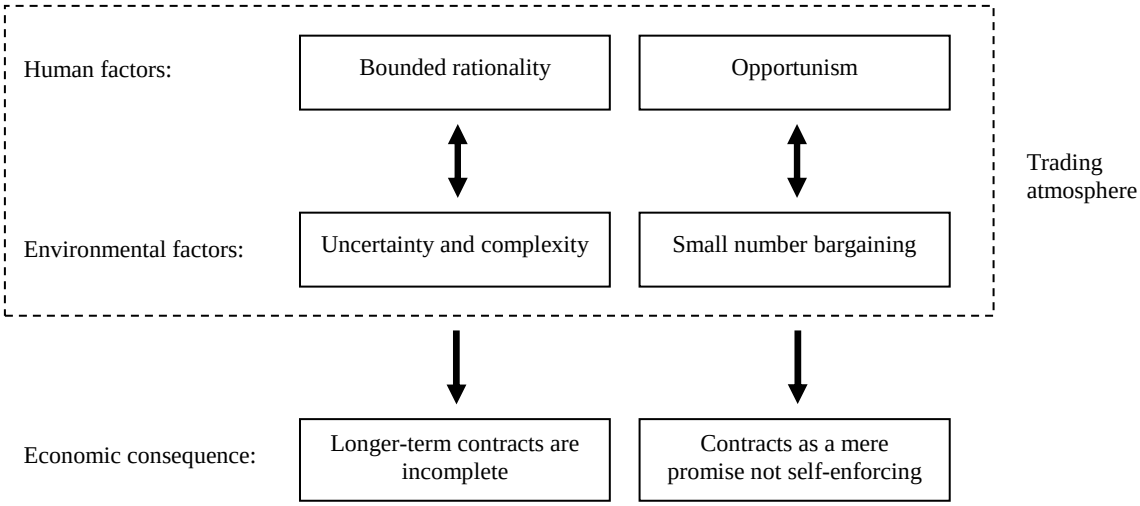
3. Empirical Evidence Based on Transaction Cost Economics

As discussed above, various governance forms co-exist in the LNG industry, including the poles of spot market transactions and vertical integration as well as numerous hybrid forms such as long- and short-term contracts, joint ventures and strategic partnerships. Frequently, the same company chooses different governance modes along alternative value chains. Furthermore, different companies follow varying strategies even though they traditionally operate in similar stages of the value chain. This chapter summarizes findings from empirical studies investigating firms' motivations to integrate vertically in the global LNG market.

3.1 Theoretical background

Transaction cost economics (see e.g. Williamson, 1975, 1985) hypothesizes that the optimal choice of governance depends on the relative costs of alternative institutional arrangements which in turn depend on the characteristics of the transaction at stake. Economic actors are assumed to be characterized by bounded rationality and may behave opportunistically. In a world in which uncertainty about the future state of nature is present, contracts will remain incomplete and do not account for all possible contingencies. This distinguishes transaction cost economics from neoclassical economics, where contracts are assumed to be complete, probability distributions of all possible future events are known and all relevant future external conditions can be considered *ex-ante* in the contracting stage. As long as there is functioning competition among trading partners, incomplete contracts are unproblematic. However, *ex-post* bilateral dependencies, as do result from investments in relationship-specific assets, will generate *ex-post* exchange hazards (e.g., maladaptation, opportunistic renegotiations). This encourages *ex-post* hold-up by the non-investing party and provides economic incentives to internalize quasi-rents into the own hierarchy, i.e. to integrate vertically.

Figure 2: Organizational failure framework



Source: Own depiction

Transaction cost economics is a comparative analysis studying governance structures under the target of economizing exchange relationships with respect to the sum of both production and transaction costs. Transactions, which differ in their attributes, have to be aligned with governance structures, which differ in their costs and competencies, in a discriminating way. Internal organization will be the efficient mode of organization only in the presence of both substantial relationship-specific investments and environmental uncertainty where the hazard of post-contractual opportunistic behavior by the counterparty would otherwise result in *ex-ante* under-investment and decreasing overall efficiency. Long-term contracts are an efficient vertical organizational form in the presence of *ex-post* bilateral dependencies if uncertainties can be dealt with by adaptive clauses (e.g. price adaptation clauses). Asset specificity without uncertainty allows for the conclusion of complete contingent claim contracts. Uncertainty without asset specificity can be dealt with in exchanges on competitive markets.

3.2 Empirical evidence

The following section summarizes empirical analysis on vertical structures in the global LNG market based on transaction cost economics and recent extensions thereof focusing on i) the likelihood of vertical integration and the impact of inter-organizational trust on the choice of more or less hierarchical governance modes; ii) the relationship between strategic positioning in the market, relationship-specific

investments, and governance form, iii) and the choice of optimal contract duration of long-term supply contracts.

Ruester (2009b) contributes an empirical analysis that examines the effect of both transaction characteristics and the institutional environment on the choice of governance in the global LNG industry. Using a dataset of 237 corporate-specific value chains, inter-organizational trust is introduced as a so-called shift parameter. First, following transaction cost economics, it is hypothesized that specific investments under uncertainty provide incentives to integrate vertically. Second, it is argued that inter-organizational trust changes the relative costs of vertical integration and non-integration and supports less hierarchical governance modes. These economic relationships are tested i) based on a probit model to explain the binary choice between vertical integration into midstream shipping and non-integration and ii) based on an ordered probit model to explain the degree of vertical integration (i.e., non-integration versus integration from upstream or downstream into midstream shipping versus integration along the whole value chain). Estimation results provide broad support for transaction cost economics by showing that relationship-specific investments in an uncertain environment drive LNG companies to invest in successive stages along the value chain. The presence of inter-organizational trust increases the likelihood of less hierarchical governance modes. The consideration of a shift parameter further enhances the explanatory power of the model supporting the need for empirical studies accounting for both transaction cost variables as well as variables capturing dynamics in the institutional environment.

Ruester and Neumann (2009) investigate corporate strategies in the emerging global market for LNG linking alternative theories of the firm in order to explain the menu of strategic positions recently observed in this dynamic market. In the first step, three alternative target market positions are defined, each supported by an underlying resource profile. In the second step, determinants that move companies towards vertical integration are investigated using the dataset of 237 corporate-specific value chains. Estimation results of a two-step decision making process confirm the positioning-economizing perspective of the firm (Nickerson, 1997). The three strategic choices of target market position, resource profile, and organizational structure are interdependent. It is shown that national oil and gas companies rely on less idiosyncratic assets than companies following a flexibility strategy, i.e., investing in a portfolio of export and

import positions, and that companies following a flexibility strategy rely on less idiosyncratic assets than chain optimizers, i.e., companies investing along a single value chain. Transaction cost economics predictions are confirmed, too. Idiosyncratic investments in uncertain environments have a positive impact on the likelihood of vertical integration.

Ruester (2009a) analyses the determinants of contract duration in order to investigate the impact of market structure on optimal governance choice. Contract duration thereby is determined based on a trade-off between the minimization of transaction costs due to repeated bilateral bargaining and the risk of being bound in an inflexible agreement in uncertain environments. Furthermore, this study adds an analysis of different dimensions of transaction frequency and their impact on governance choice to the theoretical discussion. Propositions are tested using a unique dataset including information on 261 LNG supply contracts from the beginning of the industry until today. Estimation results of a simultaneous equation model accounting for the endogeneity of the contracted volume show that the presence of high asset specificity results in longer contracts whereas the need for flexibility in today's LNG market supports shorter agreements. When firms have experience in bilateral trading, contract duration decreases. In addition, 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 importing countries.

4. Conclusions

The vertical integration of the LNG supply chain is an important issue for energy security, in particular for Europe where own natural gas resources are declining. While it may be argued that energy security is enhanced by vertical integration and long-term contracts, the opposite may also be true, since the degree of diversification may be higher in non-integrated supply chains. We have analyzed the structures of LNG-chains internationally, and find that less integration, directly or via contract duration, occurs in liberalized markets. This result also holds for Europe. We do not conclude, however, that this is a major supply risk: the market entry barriers are relatively low, diversified supply is (still) available, and some healthy competition within European importers also helps to support the market and secure supplies.

5. References

Cornot-Gandolphe, Sylvie (2005): LNG Cost Reductions and Flexibility in LNG Trade Add to Security of Gas Supply. In: IEA Prices and Taxes, OECD, Paris.

Energy Information Administration (EIA) (2003): The Global Liquefied Natural Gas Market: Status and Outlook. Washington D.C.

Eng, Gary (2006): A Formula for LNG Pricing. Report prepared for the Ministry of Economic Development, New Zealand.

Hirschhausen, Christian von and Anne Neumann (2008): Long-Term Contracts and Asset Specificity Revisited: An Empirical Analysis of Producer-Importer Relations in the Natural Gas Industry. *Review of Industrial Organization*, Vol. 32, No. 2, pp. 131-43.

International Energy Agency (IEA) (2009): World Energy Outlook 2009. OECD, Paris.

Jensen, James T. (2009a): Fostering LNG Trade: Developments in LNG Trade and Pricing. Report prepared for the Energy Charter Secretariat, Brussels.

Jensen, James T. (2009b): LNG – Expanding the Horizons of International Gas Trade. Presentation at the MIT Gas Study Group, Cambridge, Massachusetts, March 19.

Nickerson, Jackson A. (1997): Towards an Economizing Theory of Strategy. Washington University, St. Louis, Olin School of Business, Working Paper N° 97-107.

Nissen, David (2007): The Industrial Organization of Energy Systems: A Transactional Approach. Presentation at Dresden University of Technology, Germany, June 20.

Ruester, Sophia (2009a): Changing Contract Structures in the International Liquefied Natural Gas Markets – A First Empirical Analysis. *Revue d'Economie Industrielle*, n° 127.

Ruester, Sophia (2009b): Trust as a Shift Parameter in the Extended Transaction Cost Framework: A first Application to the Liquefied Natural Gas Industry. Chair of Energy Economics and Public Sector Management, Dresden University of Technology, Working Paper N° WP-RM-17.

Ruester, Sophia and Anne Neumann (2009): Linking Alternative Theories of the Firm - A First Empirical Application to the Liquefied Natural Gas Industry. *Journal of Institutional Economics*, Vol. 5, No. 1, pp. 47-64.

Williamson, Oliver E. (1975): Markets and Hierarchies: Analysis and Antitrust Implications. The Free Press, New York.

Williamson, Oliver E. (1985): The Economic Institutions of Capitalism – Firms, Market, Relational Contracting. The Free Press, New York.