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**Linking Alternative Theories of the Firm – An  
Empirical Application to the Liquefied Natural  
Gas Industry**

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# **Linking Alternative Theories of the Firm – An Empirical Application to the Liquefied Natural Gas Industry<sup>1</sup>**

## Abstract

This paper provides an empirical analysis linking two theories of the firm. We analyze corporate strategies in the emerging global market for liquefied natural gas. First, following Porter, we identify three strategic target market positions: chain optimization versus flexibility strategy versus national oil companies (NOCs). Each target market position is supported by an underlying resource profile. Second, following transaction cost economics, we hypothesize that specific investments under uncertainty provide incentives to integrate vertically. We test these economic relationships empirically applying a two-stage procedure. Estimation results show that the three strategic choices of target market position, resource profile, and organizational structure are interrelated. We show that NOCs rely on less idiosyncratic assets than companies following a flexibility strategy and companies following a flexibility strategy rely on less idiosyncratic assets than chain optimizers. An increase in hold-up potential results in a higher probability of a firm organizing transactions within its own hierarchy.

JEL-Codes: L22, D23, L95

Keywords: transaction cost economics, strategic positioning, asset specificity, vertical integration, corporate strategy, liquefied natural gas

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# 1 Introduction

In recent years, theories drawing upon institutional economics (i.e. Williamson's transaction cost economics) and strategic management literature (i.e. Porter's strategic positioning framework and/or the capabilities view of the firm) have evolved to exploit the strengths of both disciplines. The key issue is to determine why different firms within the same industry choose to adopt varying strategies. Empirical work provides strong support for transaction cost economics, but "generally does not explore how the make or buy decision for a single transaction fits into a firm's overall strategy" (Nickerson, 1997). In addition, empirical testing for alternative theories of the firm is still rather scarce. Our contribution to the literature, therefore, is an empirical analysis of corporate strategies in the emerging global market for liquefied natural gas (LNG) based on a detailed dataset including 89 operating and future exporting and importing projects worldwide.

Converting natural gas to LNG for transportation by tanker has been utilized for more than 40 years, but only recently has LNG come to play a significant role in the global natural gas market. Even though technological advances enabled transport over greater distances, it was highly capital intensive in its formative years. Markets for the most part remained regional in nature prior to the 1990s. However, as investments in LNG infrastructure grew throughout the past decade, driven by increasing natural gas demand worldwide, LNG has become a globally traded source of energy with rapidly diminishing cost. Today, it is essential to the energy supply of coastal nations such as the US, the UK, Spain, South Korea, India, and China.

The evolution of the institutional framework from monopolistic structures to competition requires fundamental changes in the organizational behavior of market participants. The rise of functioning spot markets, gains in contract flexibility, and increasing international trade have put LNG's "traditional" players under intense pressure. Global mergers and acquisitions, integration, and strategic partnerships are common practices. We observe that many of today's oil and natural gas producers and distributors are heavily engaged in all stages of the LNG value chain; thus, the global industry is now defined by a small number of large players. Indeed, Jensen (2004) argued that the developing global LNG market will be dominated by "super majors".

Several case studies have examined corporate motivations to choose alternative institutions of governance and determinants of vertical integration in commodity industries (Monteverde and Teece, 1982; Klein, 1988; Acemoglu et al., 2005). Our contribution to the literature is an analysis of the determinants of vertical integration in the LNG industry from the view of both economics and strategic management. In the first stage, we identify three alternative target market positions, each supported by an underlying resource profile; in the second stage, we investigate the determinants that move companies in the direction of vertical integration. We test our hypotheses by applying ordinary least squares (OLS), Tobit, and binary Probit models, finding results consistent with current theory that provide strong support for the so-called

positioning-economizing perspective of the firm. We show that NOCs rely less on idiosyncratic assets than companies following a flexibility strategy and that companies following a flexibility strategy rely on less idiosyncratic assets than chain optimizers. In the second step we empirically confirm transaction cost economics presumptions, i.e. that investments in idiosyncratic assets under uncertainty have a positive impact on the likelihood of vertical integration.

The paper is organized as follows: Section 2 provides an overview of the existing theoretical and empirical literature analyzing the determinants of vertical integration and a rationale for applying new institutional economics to the global LNG industry. Section 3 introduces the industry-specific context. Section 4 derives testable hypotheses, summarizes the dataset, and introduces the applied method. We present and interpret the results in Section 5 before concluding.

## **2 Literature Survey**

### **2.1 Approaches to vertical integration**

Literature provides a number of theories to explain a firm's behavior. Most empirical work investigating motivations of internal organization are based on the *transaction cost economics* framework based on Coase (1937) and further developments thereof (Williamson (e.g. 1971, 1983), and Klein et al. (1978)). This literature identifies asset specificity, uncertainty, and frequency of transactions as the most significant factors influencing transaction costs with the first being the strongest determinant of vertical integration. The hold-up problem arising from a high level of relationship-specific investments in uncertain environments with players characterized by bounded rationality results in costly ex-post bargaining, ex-ante under-investment, and decreasing efficiency. Organizing transactions within a corporation's own hierarchy by internalizing the subsequent quasi rents can avoid these problems. The transaction cost approach came into prominence during the 1980s when early stages of empirical analysis generally focused on manufacturing and the impact of investments in specific physical assets on corporate behavior (e. g. Monteverde and Teece, 1982; Klein, 1988). Subsequent research has emphasized the importance of human assets and applied the new findings to numerous industries (i.e. Acemoglu et al., 2005).

Following the more formal property rights approach (Grossman and Hart, 1986), incentives to integrate vertically are generated by the advantage of possessing residual rights of control over assets in cases where specific investments are required. Other theoretical approaches have concluded that market imperfections such as the existence of market power, barriers to entry, price discrimination, and asymmetric information favor vertical integration (Joskow, 2005).

Concurrently, the *strategic management* literature has also investigated corporate strategies and organizational forms, with "strategy" understood as a firm's selection of a certain position in the market

chosen to achieve a competitive advantage.<sup>2</sup> However, no one ideal position for all companies exists because customers and markets differ. Porter's strategic positioning framework distinguishes between cost-based and differentiation-based positions.<sup>3</sup> He further argues that for companies to survive, they must be both flexible and able to respond to structural changes within their industry.

A related stream of literature, the so-called *resource-based view of the firm*, focuses on rents derived from imperfectly imitable or substitutable resources. It distinguishes tangible from intangible resources, with the latter being the main focus. Firms' experience in an industry, reputation, established networks, or internal routines determine production and transaction costs. Similar to Porter's strategic positioning framework, the *capabilities view* is a dynamic concept in which firms need to match resources and capabilities to changes in the environment if they wish to attain optimum performance. The capabilities view suggests that the choice of internalization of activities in the firm's own hierarchy is determined, at least in part, by the relative strengths of internal and external capabilities (Langlois, 1992). Other authors have examined the relationship between relative capabilities and the choice of a governance mode (e.g. Argyres 1996).

## **2.2 Recent trends toward a synthesis of competing theories**

Empirical work provides strong support for Williamson's transaction cost economics, but "generally does not explore how the make or buy decision for a single transaction fits into a firm's overall strategy" (Nickerson, 1997). In recent years, several authors have developed theoretical approaches combining economics and strategic management literature (e.g., Day and Klein, 1987; Nickerson, 1997; Gosh and John, 1999). Whereas a market in which various firms are active is analyzed from an economic perspective, the strategic management literature examines the behavior and the performance of individual firms without any implications for the industry as a whole. This positioning-economizing perspective postulates that decisions regarding market position, resources, and governance mode are interdependent. A target market position is supported by a resource profile that in turn determines the organizational choice of a firm.

Empirical literature testing for alternative theories of the firm is still very rare. Nickerson et al. (2001) link Porter's strategic positioning framework and Williamson's transaction cost economics with an application to the international courier and small package service in Japan. They point out that the assumptions underlying both theories are not contradictory and that both theories have a consistent unit of analysis –

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<sup>2</sup> Porter (1996) pointed out that "strategy is the creation of a unique and valuable position, involving a different set of activities".

<sup>3</sup> Porter (1996) discusses "operational effectiveness" (performing similar activities better than rivals perform them) and "strategic positioning" (performing different activities from rivals or performing similar activities in different ways); later work often refers to differentiation, cost leadership, and cost focus (e.g. Nickerson et al. 2001).

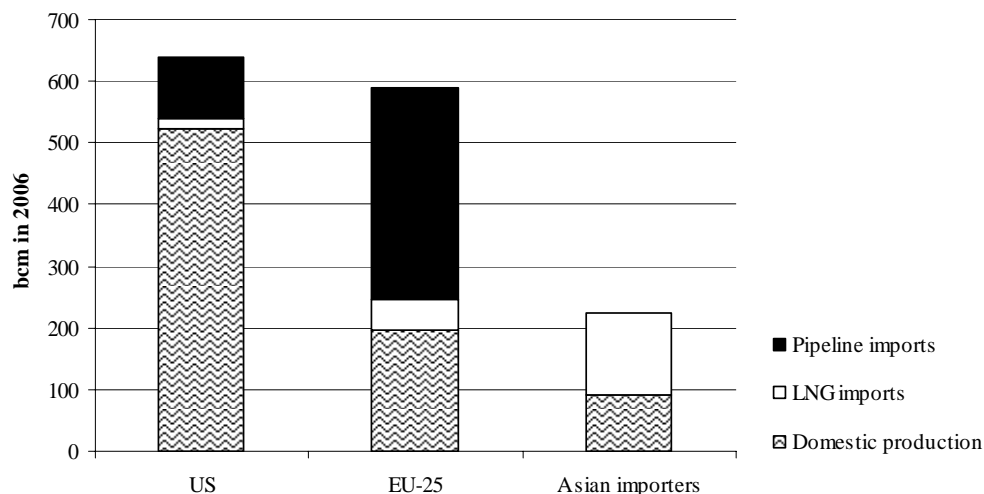
the value chain and transactions (unbundled value chain) respectively.<sup>4</sup> Nickerson et al. conclude that the heterogeneity in corporate strategies reflects the reality of firms being endowed with different feasible resource profile/organization pairings. Poppo and Zenger (1998) investigate make-or-buy decisions in information services testing transaction cost theory and the resource-based view of the firm. They conclude that in order to improve the theory of the firm, competing theories must be integrated.

We place ourselves in the continuation of this literature by analyzing corporate strategies in the global LNG industry. First, following Porter, we identify three strategic target market positions in this industry: chain optimization versus a flexibility strategy versus national oil companies. Each target market position is supported by an underlying resource profile characterized by a certain level of idiosyncrasy. Second, following transaction cost economics, we argue that specific investments under uncertainty provide incentives to integrate vertically. We test these economic relationships empirically based on a two-stage procedure.

### 3 Industry context

The transportation of natural gas is capital intensive and prices between geographic locations may differ substantially. 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 supplies and pipeline sources historically depended on LNG imports (see Figure 1).

**Figure 1: Supply structure of natural gas importing regions**



Source: BP (2007)

<sup>4</sup> Transaction cost economics makes two behavioral assumptions: actors are characterized by bounded rationality and opportunism leading to incomplete contracts. In the strategic positioning framework, no behavioral assumptions are made; Porter (1996) assumes that consumers are heterogeneous and that no strategy optimally serves all consumers.

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 natural gas 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 (Hirschhausen and Neumann, 2006).

Since the 1990s, investments in LNG infrastructure grew rapidly as worldwide natural gas demand increased significantly, leading to substantial economies of scale throughout the value chain. For example, the first liquefaction trains (Arzew in Algeria) had a capacity of 1.1 million tons per year (mtpa); today, trains with a capacity of 4 mtpa are common, and Qatar recently announced plans to construct units with 7.8 mtpa.<sup>5</sup> Tanker financing and construction schedules have benefited from new manufacturing techniques and more shipyards that can build modern vessels. Large ships lower average transport costs. Break-even of pipeline and LNG transport is now achieved at about 3,000 km (Jensen 2004).

Today, LNG is responsible for supplying the US, the UK, Spain, South Korea, India, and China among others. 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. For a detailed survey of the globalizing LNG market, see Jensen (2004).

Changes in the institutional framework (from monopolistic structures to competition) in turn demand fundamental changes in the organizational behavior of market participants. 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 today and the LNG industry is dominated by a small number of large, powerful players. We can observe that global oil and natural gas producers and distributors are frequently engaged in all stages of the LNG value chain. In addition, export projects are increasingly financed and developed by private (and foreign) interests. Former downstream monopolists of natural gas are finding their traditional markets challenged by the intrusion of oil and gas majors integrating into import markets. Vertical integration in response to market deregulation features drivers including upstream producers

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<sup>5</sup> E.g. Qatargas II and III in Qatar. Economies of scale of two 4 mtpa trains reduce the liquefaction cost of an 8 mtpa greenfield project with four 2 mtpa units by nearly 30%; an increase of one 7.8 mtpa unit leads to an additional 20% cost reduction (Jensen, 2003).

aiming to benefit from downstream margins, ownership of transportation capacities to exploit arbitraging possibilities, and distribution and power companies moving upstream to ensure margins and supply security in a period of increasing global demand.

Several authors have provided perspectives on the emerging corporate strategies employed in the LNG sector. Cornot-Gandolphe (2005) and Iniss (2004) indicate that long-term contracts are increasingly accompanied by flexible short-term agreements as well as vertical integration and strategic partnerships. Nissen (2004, 2006) identifies a new business model, the so-called “commercial LNG”.<sup>6</sup> Jensen (2004) even argues that the developing global LNG market will be dominated by “super majors”.

Figure 2 depicts the five stages of the LNG value chain: after exploration and production (stage 1), natural gas is transported via pipeline to liquefaction facilities where it is cooled to  $-160^{\circ}\text{C}$  (113K) under atmospheric pressure (stage 2) and shrinks to about 1/600 of its volume. Next, the liquefied gas is loaded into tankers containing a complex cooling system essential to keep the gas liquid during shipment to the destination countries (stage 3).<sup>7</sup> Upon arrival, tankers are off-loaded to terminals that reconvert the LNG to its original state of aggregation (stage 4). Finally, the gas is fed into the destination country’s pipeline grid, traded and sold to marketers, distributors, or power producers (stage 5), or stored for future demand.<sup>8</sup> To investigate the LNG industry from an economic as well as from a strategic perspective, the five stages of the value chain should be considered together. The structure of export or import projects is largely predetermined by exogenous factors and therefore often beyond the control of the players. Exploration and production of natural gas is directly linked to the liquefaction projects whose ownership structures in many cases are determined by national oil and gas companies. On the downstream end, national infrastructure, marketing, and distribution systems are often in place before import terminal construction. Thus our analysis concentrates on the three successive stages (upstream, midstream, and downstream) as shown in Figure 2.

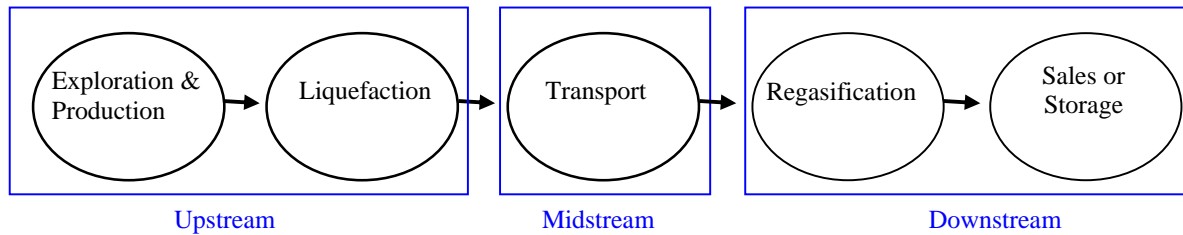
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<sup>6</sup> The LNG industry has moved away from the project-utility model (bilaterally committed value chains with the LNG export project as seller and downstream energy companies as buyers with ship ownership embedded in these long-term contracts) to the commercial structure. We observe an unbundling of transportation assets enabling flexible trades. Further, several projects operate as tolling facilities (i.e. natural gas producers rather than LNG projects act as sellers).

<sup>7</sup> Transportation infrastructure is a substantial element linking exporting and importing projects. In contrast to oil shipping, vessels for LNG transport remain dedicated assets for specific routes booked under extensive long-term contracts. However, an increasing number of vessels for uncommitted trade are now on the order books of shipyards and these will reduce dedicated asset specificity.

<sup>8</sup> Investment costs within the five stages vary significantly. Exploration and production account for 15-20% of the total costs of the LNG value chain; liquefaction for 30-45%; shipping for 10-30%; and regasification for 15-25%. Exact figures depend on factors such as distance, traded volumes, and local conditions including construction costs, port configuration, and site conditions (EIA 2003). A case study of intensive cost optimization is QatarPetroleum-ExxonMobil. The Qatargas II project invests in the largest liquefaction trains (7.8 mtpa) and largest LNG vessels (up to 250,000 m<sup>3</sup>) ever, thus benefitting from significant economies of scale.

**Figure 2: LNG value chain**



From Porter’s strategic positioning framework, we identified three possible target market positions taken by LNG firms:<sup>9</sup>

1. Flexibility strategy: Players following a flexibility strategy (e.g. BG Group, Exxon Mobil) are investing in a portfolio of LNG export and import capacities on both sides of the Atlantic or even in the Atlantic and Pacific Basins, enabling benefits from arbitraging possibilities. The control of midstream transportation capacities is a key factor required for flexible trade.
2. Chain optimizers are typically active in one import country (e.g. Gaz de France, Korea Gas Corporation), contracting or integrating along the associated value chain in order to secure supplies.
3. National oil companies are state-owned oil and natural gas companies investing upstream (e.g. Sonatrach Algeria). Their main objective is to generate revenues for the state.

Each target market position is supported by an underlying resource profile.<sup>10</sup> We note that the definition of asset specificity in the LNG industry is not straightforward. According to Nissen (2007), asset specificity is “a property of the transportation links, created by the terms of physical and commercial access” to shipping capacities. In particular, the midstream element of the value chain is of crucial importance in an industry with a relatively illiquid shipping market. Post-contractual opportunism by the counterparty may be hazardous for parties without shipping control, in other words, ex-ship/cif buyers and free-on-board sellers.<sup>11</sup> However, the transformation in the past decade to a sellers’ 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. Whereas NOCs typically invest in the upstream sector, chain optimizers hold mainly downstream positions. Employing a flexibility strategy allows players to

<sup>9</sup> We excluded a small number of observations in which a company only owns a regasification terminal and that is fully used by another traditional natural gas player (e.g., Lake Charles in the US: Southern Union is the owner but BG has capacity rights).

<sup>10</sup> Nickerson, Hamilton, and Wada (2001) define the resource profile as the “set and type (i.e. idiosyncrasy) of resources and capabilities”; Gosh and John (1999) define resources in the context of a positioning-economizing perspective as “the scarce and imperfectly mobile skills, assets, or capabilities.”

<sup>11</sup> Free-on-board (FOB): title transfer at the loading port with the buyer being responsible for shipping; cost-insurance-freight (CIF): title transfer during voyage with the seller being responsible for shipping; delivered ex-ship (DES): title transfer at the unloading port with the seller responsible for shipping.

invest in a portfolio of upstream and downstream capacities. From this we derive the following proposition:

*Proposition 1: National oil companies rely on less idiosyncratic assets than companies following a flexibility strategy; companies following a flexibility strategy rely on less idiosyncratic assets than chain optimizers.*

According to Williamson's transaction cost approach, idiosyncratic assets in uncertain environments lead to the hazard of opportunistic behavior by the counterparty. Asset specificity is the strongest determinant of vertical integration. Organizing transactions within a firm's own hierarchy will avoid these costs. Hence we derive:

*Proposition 2: Idiosyncratic assets in uncertain environments increase the probability of vertical integration along the LNG value chain.*

We define an econometric model analyzing this two-stage decision-making process. In the first stage we examine how players choose a resource profile supporting their target market position and in the second we study the determinants that drive players to vertical integration.

## **4 Data and Methodology**

### **4.1 Data**

Our global industrial dataset was compiled from publicly available information complemented by interviews with industry experts. It includes capacities, ownership structures, investment costs, financing structures and expansion plans for liquefaction and regasification projects; data on LNG's worldwide tanker fleet, including vessels currently listed in shipyard order books; and analyses of contracting partners, supply facilities, contracted volumes, and contractual durations.

We first identify actual value chains based on the dataset's 67 import and 22 export projects and then analyze individual companies' activities throughout the chains.<sup>12</sup> Omitting observations with missing data, our sample consists of 253 corporate-specific value chains, of which 138 are situated in the Atlantic Basin and 115 correspond to Asia-Pacific trade. Precise definitions of the endogenous and exogenous variables employed follow.

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<sup>12</sup> All of the existing regasification and liquefaction plants worldwide and projects under construction and planned to be operational up to 2010.

## Endogenous variables

Our first prediction relates the extent of idiosyncratic assets to the choice of a target market position. To test for this relationship, we define the extent of idiosyncratic assets of a player (SPECIFIC) by the ratio of regasification capacity ( $r_{i,year}$ ) over the sum of regasification and liquefaction capacity the player controls in the respective year ( $r_{i,year} + l_{i,year}$ ). The variable increases with the share of regasification capacities in a firm's LNG portfolio, mirroring the lock-in situation of a player investing downstream in a sellers' market. It is continuously distributed between 0 and 1 (including these threshold values):

$$SPECIFIC_i = \frac{r_{i,year}}{(r_{i,year} + l_{i,year})}$$

Our second prediction is derived from transaction cost economics. For an empirical test we design an evolution criterion based on whether a company integrates vertically; the unit of analysis is whether or not a firm integrates from upstream or downstream, depending on its origin into the midstream shipping stage. We classify both equity relationships and long-term charter contracts as vertical integration. The dependent variable VI is a binary discrete measure taking the value of one if we observe vertical integration of the player, and zero otherwise:

$$VI_i = \begin{cases} 0 & \text{no vertical integration} \\ 1 & \text{vertical integration along the value chain} \end{cases}$$

## Exogenous variables

Proposition 1 describes the relationship between a target market position and the resource profile (i.e. the level of idiosyncrasy of a player's assets). We use dummies indicating chain optimizers (CHAIN) and national oil companies (NOC) as exogenous variables.<sup>13</sup> The flexibility strategy (FLEX) is the omitted position. Hence, Proposition 1 indicates a positive relation between SPECIFIC and CHAIN and a negative relation between SPECIFIC and NOC.

Proposition 2 refers to the impact of idiosyncratic assets and uncertainty on the likelihood of vertical integration. Transaction cost economics predicts that asset specificity is the strongest determinant of vertical integration. Theory shows that the most efficient solution is trade on a short-term market for

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<sup>13</sup> The allocation of all players active in the LNG industry to one of the three target market positions (i.e. flexibility strategy, chain optimization, and NOC) was accomplished based on our own valuation, and verified in interviews with natural gas market experts.

exchange relationships not involving any investment in specific assets. Markets become inefficient as bilateral dependencies – resulting from investments in specialized assets – arise. Specific investments in environments without uncertainty can be secured through long-term contracts. In contrast, the existence of uncertainty results in vertical integration being more efficient.

Due to the high capital intensity of infrastructure investments, uncertainties about the scope of natural gas fields or price developments, and the lifetime duration of these projects, investors generally face different risks. In addition, natural gas fields are often located in politically uncertain regions.<sup>14</sup> The variable for political uncertainty (UNCERT) is based on POLCON (Henisz, 2000), an index that measures the degree of constraints on policy change in a country averaged for five-year periods since 1960.<sup>15</sup>

Control variables: To account for changes in corporate strategies over time we include a dummy variable indicating value chains that came into operation after 1999 (D2000). We expect that players will encounter a changing environment given the industry’s rapid expansion and that they must select or adapt strategies to maintain or gain competitive advantages as discussed, for example, in Porter (1996).

We use the dummy variable ATLANTIC to control for differences in corporate strategies resulting from regional factors that vary between the Atlantic Basin market (deliveries to Europe and North America) where LNG trading hubs already exist or are developing, and Asia-Pacific trade where buyers depend strongly on LNG imports.

We calculate the variable CAPOWN as the ratio of the accumulated liquefaction and regasification capacities controlled (owned or contracted) by a global player over the sum of worldwide liquefaction and regasification capacities in operation at the end of the respective year  $(r_{i,year} + l_{i,year}) / (r_{total,year} + l_{total,year})$ .

STATE, another dummy variable, identifies state-owned entities, thus allowing for differences in corporate strategies due to a different ownership structure. Finally, we use the firm’s assets value (ASSETS) as a proxy variable for firm size and financial strength. For a survey of all exogenous variables see Table 1.

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<sup>14</sup> For example, the guerrilla activities of Aceh separatists in Western Sumatra (Indonesia) caused a temporary shutdown of the Arun liquefaction facility in 2001.

<sup>15</sup> Various studies have shown that this index is suitable for testing transaction cost approach hypotheses. We adjusted the POLCON index so that a high value expresses “high risk” and a low value “low risk”, hence our proxy variable RISK 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.

**Table 1: Exogenous variables and expected effect on the dependent variable**

Characteristic	Proxy	Denotation	Exp. Sign
Proposition 1 (dependent variable: SPECIFIC)			
Chain optimizer	Dummy variable indicating chain optimizers	CHAIN	+
National oil company	Dummy variable indicating national oil companies	NOC	-
Proposition 2 (dependent variable: VI)			
Asset specificity	Variable measuring the level of idiosyncratic assets	SPECIFIC	+
Project uncertainty	POLCON index (adjusted to [1-POLCON])	UNCERT	
Control variables			
Start-up date	Dummy for start-up after 1999	D2000	
Industry characteristics	Dummy for value chain in Atlantic Basin	ATLANTIC	
Participation in industry	Capacity controlled by the firm (percent of total cap.)	CAPOWN	
Company type	Dummy for state-owned entity	STATE	
Financial resources	Firm size (assets in mn. USD)	ASSETS	

Table 2 gives summary statistics of the 253 observations in the dataset. More than 40% of the observations are chain optimizers, 21% are NOCs, and 33% players follow a flexibility strategy. There is a 55% average likelihood of vertical integration into midstream shipping. More than 50% of all observations came (or come) into operation in the period 2000 to 2010, mirroring the industry's rapid expansion. Slightly more than half of the observations are situated in the Atlantic Basin. Players control between 0.1% and 30.3% of worldwide liquefaction and regasification capacities during the observation period. 33% of the value chains are state-owned entities. Corporate size ranges from USD 358mn (Italian Enel) to USD 279bn (Japanese Nippon Oil Corporation).<sup>16</sup>

**Table 2: Summary statistics**

	SPECIFIC	VI	CHAIN	NOC	UNCERT	D2000	ATLANTIC	CAPOWN [%]	STATE	ASSETS [mn USD]
Mean	0.479	0.547	0.394	0.213	0.604	0.531	0.547	3.932	0.370	630747
Median	0.310	1	0	0	0.460	1	1	2.138	0	37,416
Max	1	1	1	1	1	1	1	30.277	1	195,265
Min	0	0	0	0	0.130	0	0	0.064	0	358
Std. Dev.	0.447	0.499	0.490	0.410	0.379	0.500	0.499	5.092	0.484	63,661
N	253	253	253	253	253	253	253	253	253	253

<sup>16</sup> We assumed a firm's assets value (USD 10 billion) if no data was available (e.g. Pertamina, National Libyan Oil Company, and EGPC).

## 4.2 Methodology

We sequentially estimate two separate regression models: the relationship between a target market position and the level of idiosyncratic assets, and the impact of the firm's resource profile (with respect to the level of idiosyncrasy) on the likelihood of vertical integration.. Following Proposition 1 that refers to Porter's strategic management literature, we hypothesize that each target market position is supported by an underlying resource profile:

$$\begin{aligned} SPECIFIC_i = & \alpha_0 + \alpha_1 CHAIN_i + \alpha_2 NOC_i + \alpha_3 UNCERT_i + \alpha_4 D2000_i \\ & + \alpha_5 ATLANTIC_i + \alpha_6 CAPOWN_i + \alpha_7 STATE_i + \alpha_8 \log(ASSETS_i) + \varepsilon_i \end{aligned} \quad (1)$$

where the error term  $\varepsilon_i$  is expected to follow a normal distribution. For econometric reasons, all control variables used in equation 2 are included in equation 1 above. We estimate equation 1 using an OLS model. Since we observe a certain accumulation of observations at the threshold values of zero and one, we also employ a Tobit model to verify estimation results.

In the second step we examine, based on Williamson's transaction cost approach, the impact of specific investments on a firm's choice of governance form. Following Proposition 2 we expect that idiosyncratic assets in combination with the observed uncertainty relate positively to the likelihood of vertical integration, with asset specificity being the strongest determinant of the choice to organize transactions within the firm's own hierarchy. To account for endogeneity, we replace the observed values of SPECIFIC by their predicted values SPECIFIC\_F calculated from equation 1 (Maddala 1983).<sup>17</sup> We also include an interaction term to account for transaction cost approach predictions that specific investments in combination with uncertainty enhance the probability of vertical integration. From this we obtain:

$$\begin{aligned} VI_i = & \beta_0 + \beta_1 SPECIFIC\_F_i + \beta_2 UNCERT_i + \beta_3 (SPECIFIC\_F_i \cdot UNCERT_i) \\ & + \beta_4 D2000_i + \beta_5 ATLANTIC_i + \beta_6 CAPOWN_i + \beta_7 STATE_i \\ & + \beta_8 \log(ASSETS_i) + u_i \end{aligned} \quad (2)$$

where the error term  $u_i$  is expected to follow a normal distribution. Having defined the dependent variable as binary variables, we apply a Probit estimation model.<sup>18</sup>

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<sup>17</sup> Since unobservable variables that may influence the level of idiosyncratic assets (SPECIFIC) could be correlated with unobservable variables having an impact on the probability of vertical integration into shipping, we account for this endogeneity problem to prevent biased estimation results (e.g., an underestimation of the effect of idiosyncratic investments on the likelihood of vertical integration).

<sup>18</sup> Probit estimation models are employed if the dependent variable is defined as a binary choice variable with the error term assumed to be distributed normally. Probit estimation models are preferred to logit estimation models

## 5 Estimation Results and Interpretation

Table 3 provides the estimation results of the two models; both hypotheses are confirmed empirically. The p-values of F- and LR-statistics respectively (both < 1%) show that the null hypotheses of all slope coefficients equaling zero must be rejected for both estimations. Adjusted R<sup>2</sup> and Pseudo R<sup>2</sup> of 0.363 (0.369) and 0.265 (0.252) for OLS and Tobit-based equation systems support the explanatory power of the models.

**Table 3: Estimation results**

Independent variables	Proposition 1 Dependent variable: SPECIFIC		Proposition 2 Dependent variable: VI	
	OLS model	TOBIT model	1 <sup>st</sup> stage OLS	1 <sup>st</sup> stage TOBIT
CONSTANT	1.183 *** (0.206 )	2.205 *** (0.550 )	-6.506 *** (1.200 )	-6.109 *** (1.169 )
CHAIN	0.132 * (0.067 )	0.178 (0.162 )		
NOC	-0.563 *** (0.092 )	-1.667 *** (0.266 )		
SPECIFIC_F			1.837 ** (0.856 )	2.027 ** (0.885 )
UNCERT	-0.050 (0.065 )	-1.143 (0.162 )	-1.124 ** (0.569 )	-0.868 (0.600 )
(SPECIFIC_F*UNCERT)			2.646 ** (1.102 )	2.026 * (1.091 )
D2000	0.047 (0.048 )	0.121 (0.123 )	0.429 ** (0.195 )	0.430 ** (0.197 )
ATLANTIC	0.082 (0.052 )	0.099 (0.134 )	-0.123 (0.199 )	-0.032 (0.196 )
CAPOWN	0.018 *** (0.004 )	0.063 *** (0.016 )	-0.003 (0.023 )	-0.001 (0.022 )
STATE	0.155 ** (0.067 )	0.323 * (0.174 )	0.794 *** (0.252 )	0.851 *** (0.253 )
LOG(ASSETS)	-0.078 *** (0.018 )	-0.176 *** (0.047 )	0.513 *** (0.087 )	0.454 *** (0.081 )
Adjusted R <sup>2</sup>	0.363	0.369		
Pseudo R <sup>2</sup>			0.265	0.252
p-value F-statistic	0.000			
p-value LR-statistic			0.000	0.000
N	253	253	253	253

\*\*\* Statistically significant at a 1%-level; \*\* statistically significant at a 5%-level; \* statistically significant at a 10%-level; standard errors in parentheses

based on a comparison of different goodness-of-fit indicators (Akaike-, Schwarz- and Hannan-Quin information criteria).

Our empirical results provide broad support for Proposition 1 – the estimation coefficient of chain optimizers has a positive sign (statistical significance at the 10% level for the OLS model) and the estimation coefficient of NOCs has a negative sign (statistical significance at a 1% level for both models). Hence, we can confirm that NOCs rely on less idiosyncratic assets than companies following a flexibility strategy, and companies following a flexibility strategy rely on less idiosyncratic assets than chain optimizers.

The results of the second-stage estimation provide broad support for transaction cost predictions. Asset specificity (or idiosyncrasy of investments), as the strongest determinant of vertical integration, shows the expected positive sign (5% significance level). Uncertainty itself tends to have a negative impact on the probability of vertical integration. However, even though uncertainty itself does not lead to vertical integration (Williamson 1971), its presence intensifies the impact of specific investments on a player's motivation to organize transactions within its own hierarchy. As shown by the interaction term (SPECIFIC\_F · UNCERT), we can confirm that uncertainty enforces the impact of idiosyncratic investments; asset specificity in combination with uncertainty has a strong positive impact on a firm's incentive to integrate vertically.

Statistically significant control variables provide several interesting findings. The variable STATE is significant in both models and under both OLS and Tobit estimation procedures in the first stage. In contrast to private firms, state-owned entities tend to invest in assets with a higher level of idiosyncrasy; the share of regasification capacities in their LNG portfolios is larger on average. This can be explained by the fact that in the first decades of the LNG industry, mainly national natural gas companies and distributors invested in LNG import capacities, even though we observe the move to privatization (e.g., Gas de France, ENI). As suggested by theory, we find that the likelihood of vertical integration is on average also higher for state-owned entities.

Players controlling a larger share of world LNG (regasification and liquefaction) capacities (CAPOWN) show a higher extent of investments in specific assets. The variable controlling for the start-up date of the value chain (D2000) indicates that vertical integration has become a more common organizational mode throughout the industry. This reflects global players' efforts to establish a portfolio of export and import positions in order to benefit from arbitrage potentials. We observe that access to flexible transport capacities (e.g., via integration into midstream shipping) is the key to successful employment of this strategy. Rapid industrial expansion accompanied by a restructuring process prompts firms to internalize risks inherent in the capital-intensive industry via strategic repositioning and reshaping.

For the variable measuring a firm's financial strength (ASSETS) we find that investments in specific assets decrease with a higher assets value. A possible explanation is that most capital-intensive investments are required upstream (exploration, production, and liquefaction). In contrast, the value of assets is positively related to the likelihood of vertical integration, an indication that larger firms have the

financial capabilities necessary to invest in numerous capital-intensive LNG (export and/or import and shipping) facilities.

## **6 Conclusions**

This paper provides empirical evidence for combining different theories of the firm. Recent theoretical literature argues that economic and strategic management approaches should be linked to explain companies' behavior in dynamic markets. We analyze corporate strategies in the rapidly developing global LNG industry using Williamson's transaction cost approach and Porter's strategic management framework.

The "LNG rush" forecasted during the early years of this decade has brought an increase in regasification capacity of about 45% since 2000. A large number of additional terminals and the expansion of existing facilities are approved, under construction, or already completed; countries not currently benefiting from LNG flexibility are considering investments in the near future (e.g., Wilhelmshaven in Germany, Gdansk in Poland, Krk in Croatia, Mariveles on the Philippines). Rapidly increasing worldwide demand and the ongoing process of deregulation in downstream markets have brought fundamental changes in corporate behavior such that the global LNG industry is now characterized by flexible long-term contracts accompanied by short-term agreements. Many companies are investing in regionally diversified LNG portfolios and integrating vertically to internalize risk factors resulting from investments in capital intensive infrastructures. The control of transport capacities is a key factor in order to benefit from cross-trade opportunities.

Using a two-stage decision-making process, we test two propositions on corporate strategies in the LNG industry. First, based on Porter's strategic positioning framework, we identify three possible target market positions: chain optimization (investments in infrastructure along a single value chain) versus a flexibility strategy (investments in a portfolio of LNG export and import positions) versus national oil companies (mainly upstream activities). Empirical results provide broad support for our industry-specific predictions and support the positioning-economizing approach hypothesis of an interrelation between the three strategic choices of target market position, resource profile, and organizational structure. We show that NOCs rely on less idiosyncratic assets than companies following a flexibility strategy and that those companies following a flexibility strategy rely on less idiosyncratic assets than chain optimizers. Second, we use transaction cost economics to analyze the determinants of vertical integration. Our results confirm the theory's predictions and show that idiosyncratic investments in uncertain environments lead to a motivation to organize transactions within a firm's own hierarchy.

As Porter (1996) argues, "a company may have to change its strategy if there are major structural changes in its industry." Although the LNG industry already has undergone significant changes, several dynamics in industry characteristics remain. Nissen (2006) discusses the emergence of so-called "merchant

structures” upstream and downstream. Three ways of implementing merchant structures into an LNG value chain are feasible: i) the expansion of a project to an integrated merchant (e.g. QatarPetroleum-ExxonMobil); ii) the elimination of a project from the value chain (e.g. Idku/Egypt); and iii) embedding trading optionality in long-term supply contracts (e.g. Sempra Energy in Tangguh/Indonesia). Further qualitative or quantitative analysis on the LNG industry should address these recent developments.

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