

Long-Term Contracts and Asset Specificity Revisited: An Empirical Analysis of Producer–Importer Relations in the Natural Gas Industry

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Abstract This paper discusses long-term contracts as a particular organizational form situated somewhere between full vertical integration and short-term, market-based trading in the natural gas industry. We focus on the determinants of the duration of contracts under changing technical, economic, and institutional conditions. Using 311 long-term contracts we find that duration decreases as international market structures grow more competitive, and that contracts linked to an asset-specific investment extend, on average, three years longer.

Keywords Asset specificity · Econometric analysis · Contracts · Natural gas · Transaction costs · Institutions

1 Introduction

Long-term contracts are a particular organizational form that is situated somewhere between full vertical integration and short-term, market-based trading. Commodity markets lend themselves particularly to the study of long-term contracts, because they are frequently used in sectors such as natural gas, oil, non-ferrous metals, and iron ore (Joskow 1987). After a first peak of empirical research on the determinants of long-term contracts in the 1980s, the academic and policy debates are now rebounding. This regained interest is driven by new theoretical developments in institutional

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and contract theory, reduced security of global supply, and the increases in short-term prices, most drastically of crude oil prices. It sometimes seems as if relationships, such as long-term contracts, are *en vogue* again.

The traditional explanation for the existence of the institutional “hybrid”, long-term contracts is based on transaction cost economics (Williamson 1975, 1985) and still valid today: Long-term contracts can help to minimize the transaction costs for two parties engaging in a commitment involving significant specific assets but where full vertical integration is not feasible. Long-term contracts including requirement clauses, price indexation, liquidation damages, arbitration, and other provisions have been identified as a means to overcome the hold-up problem without vertical integration. Asset-specific investments and uncertainty imply high transaction costs that can be reduced by long-term contracts as an alternative to “simple” short-term contracting (Williamson 1983). Recent developments in (incomplete) contract theory have a focus on the incentive design of arrangements (e.g., Hart 1995).

Contractual arrangements have been the focus of analyses and research applications, ranging from traditional activities such as R&D cooperation (Oerlemans and Meeus 2001) to less-conventional sectors, such as the winegrape industry (Goodhue et al. 2003). Some of the first empirical applications of transaction cost theory studied the energy sector: Joskow (1985, 1987) demonstrated that the duration of contracts in the U.S. coal industry related positively to the level of asset-specificity. Crocker and Masten (1988) and Masten and Crocker (1985) were the first to test the influence of different regulatory regimes in the U.S. natural gas sector by examining 245 American natural gas contracts that contained detailed information on prices, quantities, and take-or-pay provisions.

Given the breadth of literature on long-term contracts it may seem surprising that few papers study the dynamics of these contracts and the factors determining the evolution of important attributes of these contracts, such as contract duration or take-or-pay obligations. In this paper, we try to contribute to the understanding of the changing nature of long-term contracts and the determinants thereof. We are convinced that the natural gas sector lends itself particularly to the analysis of the dynamics of long-term contracts: The industry was traditionally developed based upon long-term contractual relations between producers and trading companies.

However, rapid technical change, such as the advent of large-scale transportation possibilities for liquefied natural gas (LNG), and institutional changes, such as market restructuring, have changed the nature of the industry significantly over the last two decades. Thus, bilateral long-term relationships are giving way to an emerging global natural gas market with multiple relations among the players along the value-added chain (Hartley and Brito 2007).

These structural changes have appeared clearly in the more reform-oriented countries such as the U.S. (in the 1980s) and the UK (1990s). Empirical evidence about the changing nature of long-term contracts in the U.S. and the UK suggests an inverse relation between natural gas sector restructuring and contract duration. In both countries, long-term contracts between natural gas producers and wholesale buyers have lost market share, even though they have not entirely disappeared with market restructuring. Overall, average contract length has shortened significantly, from an average of 20–25 years in the 1980s to approximately 8–15 years today (IEA 2004, p. 110).

Earlier pieces of research have analyzed contractual relations in the natural gas sector in different institutional settings: Crocker and Masten (1988) and Masten and Crocker (1985) identified the changing regulatory environment and industry restructuring as the chief determinants of long-term contracts in natural gas. They also asserted that the take-or-pay provisions inherent in traditional contracts provide sufficient mechanisms to avoid breach and costly renegotiations. Mulherin (1986) showed that governmental regulation in the U.S., mainly the Public Utility Holding Company Act of 1935 (PUHCA) and the Natural Gas Act of 1936, led to more reliance on long-term contracts, take-or-pay provisions, and price adjustments.

Hubbard and Weiner (1986) analyzed the take-or-pay provisions of long-term natural gas supply contracts following the deregulation of wellhead prices in the U.S. (Natural Gas Policy Act of 1978). Their sample of 884 natural gas contracts revealed a minor impact on mean take-or-pay requirements; this corresponds to MacAvoy (1962) findings. Doane and Spulber (1994) argued that open access to the transportation system reduced the potential for a bilateral monopoly between pipeline owners and field producers and the related contractual hold-up problem, and thus the transaction costs associated with assuring contractual performances also decreased.

In this paper, we go beyond the U.S.-context upon which the literature has concentrated thus far. Instead, we focus on international natural gas markets and on the contracts between natural gas producers around the world and their downstream trading partners. Our research continues earlier work on long-term contracts in Europe (Neumann and Hirschhausen 2004): Based on a dataset of long-term contracts concluded by European importers since 1985, we have shown that the length of take-or-pay contracts for natural gas supply to Europe dropped significantly over the past two decades, largely driven by restructuring efforts in the EU.

In a theoretical paper, Neuhoff and Hirschhausen (2005) took the analysis a step further by accounting for different short-run and long-run demand elasticities, and revealed that producers prefer institutional arrangements that favor long-term contracting in situations where long-run demand elasticity is significantly higher. The energy sector inquiry carried out by the European Commission's Directorate General for Competition (European Commission 2005b) identified the major barriers in the development of a truly competitive internal market for electricity and natural gas based on a survey of 242 long-term contracts; it criticized lengthy contract durations.

This paper enlarges the scope to world-wide trading of natural gas, and it has no normative scope. Instead, we try to establish some facts about the determinants of long-term contracts, which we will then try to interpret using transaction cost economics. When studying the development of long-term contracts in liberalizing natural gas markets world-wide, our focus will be on the determinants of the duration of contracts under changing technical, economic, and institutional conditions.

We want to test two related hypotheses:

H₁: In the course of the transition from a monopoly industry to competitive market structures, long-term contracts lose some of their effectiveness. We therefore expect to find an inverse relation between the degree of market restructuring (in Europe called liberalization) and contract length. This hypothesis is both grounded in transaction cost theory and in empirical evidence—e.g., in the U.S. and the UK. The

development is likely to be driven by the increasing number of market players, the growing liquidity and depth of spot markets that provide efficient tools for portfolio risk management, and also the inherent flexibility that accompanies the expansion of the world's LNG trade;

H₂: Long-term contracts will continue to play a more important role in deals where large-scale, asset-specific investment decisions are at stake. In these cases, the transaction-cost reducing character of long-term contracts comes into play. We therefore expect a positive relationship between contract length and the asset specificity of investments (*ceteris paribus*).

The rest of the paper is structured so that we derive empirical tests for the two hypotheses. The next section describes the natural gas industry in more detail, in particular the dynamics that it has undergone in terms of technical, institutional and economic characteristics. From a “boring” monopolistic industry, the natural gas industry has turned into a dynamic, competitive, and environmentally friendly industry that is receiving increased attention from the corporate sector and from public policy. In Section 3 we present the data and formulate the hypotheses and model specification to be tested. To this end, we describe the unique set of 311 long-term contracts that we have put together, solely based on public information. Based on this dataset, we test the impact of structural and institutional variables on contractual duration. Among other findings, we note that duration decreases significantly as natural gas markets become more competitive (Section 4). We can also confirm the second hypothesis: Contracts that involve large scale, asset-specific investments (e.g., new natural gas field development, or construction of large infrastructures) are longer in duration than are other contracts where no specific investments are at stake. Section 5 concludes.

2 Technical, Institutional, and Economic Changes in the Natural Gas Industry

2.1 The Value-added Chain

Natural gas is a colorless and odorless non-renewable combustible mixture of hydrocarbon gases. This fossil fuel is commonly produced in association with oil, although there are also non-associated reservoirs. Natural gas is refined after production: other hydrocarbons are removed, leaving clean, ‘dry’ natural gas that is almost pure methane.¹

Historically the international trade of natural gas has been determined by the geographical dispersion of reserves, the demand centers, and advances in transportation technology. Clean natural gas is either transported via pipelines to consuming regions or in the form of liquefied natural gas (LNG) in specially designed tankers. Large customers or local distribution companies (LDCs) sell the product to end-users such as commercial and industrial customers, gas-dependent industries, transportation companies, and utilities (for both commercial and residential usage).

¹ For a non-technical survey of the natural gas industry, see [IEA \(1998\)](#).

Traditionally, the natural gas industry was developed on long-term contracts linking sellers and buyers in a bilateral monopoly for a long period with strictly defined obligations for both. Purchasers are required to pay for a pre-specified minimum quantity of natural gas whether or not that quantity is actually taken and producers are required to deliver this quantity (Masten 1988). These contracts covered the financing of exploration and production of natural gas fields in remote places, such as Western Siberia, and the capital-intensive infrastructure to bring the natural gas to the marketplace (pipelines, storage facilities, etc.) Natural gas exploitation is limited to a small number of regions worldwide, with the largest reserves located in Russia and the Middle East. Additionally, production in Oceania, Africa, and Northern Europe played a significant role with respect to European markets until recently.

During the past 25 years, the natural gas industry underwent significant structural changes in almost all countries of the world. As in other network industries, natural gas witnessed attempts to create competitive markets, restructure vertically integrated monopolies, and introduce sector-specific regulation (see Dixon and Easaw (2001) for the UK, and Joskow (2005) for a general survey of the lessons from de- and reregulation). Technical progress was rapid also, as evidenced by the development and wide diffusion of LNG technologies that revolutionized international natural gas trading. This section describes some of the structural changes that we quantified that yielded testable hypotheses for our empirical observations.

2.2 Economies of Scale and Decreasing Capital Intensity

During the last decades, the natural gas industry has reaped significant economies of scale, which has led to reductions in the capital intensity of operation. This is particularly the case for LNG, but it also holds true for traditional pipeline technology. In the LNG chain, investment costs per unit of output (here: million British thermal units, MBtu) has decreased from well above \$4.50/MBtu in the early 1990s, to about \$3/MBtu today (in 2004 US\$). The capital intensity of pipeline transport has been reduced, too, as larger diameter pipes are used, and higher pressure differentials allow higher flows.

As transportation technology improves and economies of scale are reaped upstream, mid-stream, and downstream, the capital intensity of the natural gas value-added chain has diminished gradually. *Ceteris paribus*, lower capital intensity leads to a lower level of risk and should therefore reduce the contract duration over time.

2.3 Development of Liquid Spot and Forward Markets

The emergence of liquid spot and future markets has also affected the need for long-term contracting. The “by-products” of liberalized markets are the spare quantities of commodities unsold under long-term contracts, and market buyers and traders who understand risk and are willing to trade at short notice. Similar to developments in the world oil markets in the 1970s, spot, short-term, and longer-term forward markets have emerged in the course of industry restructuring.

These markets generally develop at locations where several sources of supply and demand connect, such as Henry Hub (USA), NBP (UK), and Zeebrugge (Belgium). Increasing churn ratios² and absolute trading volumes imply that these markets can carry a part of the risk previously covered by long-term contracts. The emergence of trading places has also facilitated the integration of international natural gas markets, which further weakened the importance of long-term contracts.

Uncertainty in natural gas trade diminishes with the development of spot markets and their associated liquidity. Moreover, producers of natural gas are moving downstream to reap benefits. Therefore, we may expect to observe a negative influence on contractual duration varying with producing regions and market consumption.

2.4 Growing Number of Market Participants

Market restructuring, the emergence of spot trading and the increased use of natural gas downstream have significantly reduced barriers to entry and increased the number of participants active in these markets. Upstream, one observes new producers and exporters, such as Nigeria, Trinidad, Libya, Egypt, and even Australia, which have joined incumbents such as Algeria and Russia. Downstream, multi-utility companies and electricity generators have entered the market; this is particularly the case in Europe after liberalization began in the late 1990s ([European Commission 2005a](#)).

These new participants, and some of the incumbents, apply alternative instruments for trading pipeline gas and LNG, with more flexibility in duration, volumes, and re-selling of natural gas. Using a traditional microeconomic search model, [Hartley and Brito \(2007\)](#) show that an increasing number of market participants in natural gas markets encourages more short-term trade, as compared to the old regime of bilateral monopolies. In parallel with Hartley and Brito, we expect that the additional numbers of producers and wholesale traders will enhance opportunities other than long-term contracts, and lead to reductions in contractual duration.

2.5 Reduced Asset Specificity of Investment

In addition to reduced per-unit investment cost, the nature of the asset specificity has also changed. In the early days of international natural gas trading, highly asset-specific investments took place that needed to be backed by long-term contracts. Thus, the development of trade between large producers such as Canada or Russia and consumers such as the U.S. and Western Europe required intensive investment in upstream natural gas fields, pipeline infrastructure, and downstream distribution networks. The investments were often project-specific, leading to high asset specificity and subsequently to issues of quasi-rent negotiations, and reliance upon long-term contracts.

The situation has shifted, though, in part due to the development in up-, mid- and downstream markets. Upstream, contracts are no longer field-specific but instead are tied to the overall natural gas exports of a country or producer. Thus, investments

² The amount of times a unit of natural gas is resold before delivery.

are no longer contract-specific: a given field can serve a variety of contracts.³ The emergence of more trading companies also diminishes asset specificity, since the loss of having to move from the first-best to the second-best match (i.e., another trader) is reduced. Mid-stream (i.e., the transportation chain), most of the necessary long-distance pipeline connections and distribution networks are already in place. Therefore, new contracts require significantly less investment in specific infrastructure capacity expansion.

The trend towards decreased asset specificity for industry-related investment implies a reduced reliance on long-term contracts to resolve potential hold-up conflicts. [Hartley and Brito \(2007\)](#) suggest that for LNG, the lower asset specificity of a project is reflected in the trend to more spot and short-term trade without finalizing long-term agreements prior to investing in regasification terminals. This suggests *ceteris paribus* reduced contractual duration over time, and greater duration only when asset-specific investments are at stake.

2.6 Hypotheses for Empirical Tests

The technical, economic, and institutional changes in the natural gas industry should affect the nature of the long-term contracts that prevail in that sector, thus triggering changes in the industrial organization. Transaction costs are expected to increase with growing asset specificity and uncertainty, and to decrease with the frequency of transactions ([Williamson 1985](#)). The developments outlined above should therefore reduce transaction costs and reduce the use of traditional long-term contracts linked to the transaction cost perspective. This leads us to postulate the following hypotheses with respect to the dynamics of contract duration:

H₁: Market restructuring and the emergence of a global natural gas market reduces the duration of long-term contracts;

H₂: Other things being equal, contracts that imply large-scale, asset-specific investments will have longer contract duration than do other contracts.

3 Data and Model Specification

Our dataset includes information on 311 long-term contracts struck between natural gas producers and consumers or traders between 1964 and 2006. The data are based on publicly available sources and have been verified through expert interviews. Table 1 provides the summary characteristics of these contracts. 122 contracts cover natural gas deliveries through pipeline, and 189 through overseas transport as liquefied natural gas (LNG). 154 contracts are signed for deliveries to continental Europe, 122 to Asia, 31 to either the U.S. or the UK market (dummy variable C_US_UK), and 4 other destinations.

The data also cover all major natural gas producing regions: Oceania (P_Oceania), Europe (P_Europe), Africa (P_Africa), the Middle East (P_ME) and Russia (P_Russia)

³ These developments are mirrored in the abatement of the destination clause found in European contracts.

Table 1 Summary statistics

Variable	Observations	311			
	Description	Mean	Min.	Max.	Std. Dev.
CD	Contract duration (years)	19.53	2	36	6.71
TVol	Total contracted volume (bcm)	50.62	0.32	360	62.64
Dummy variables:					
PROJECT	Contract signed to dedicated project	D = 1: 149 observations			
ENTRANT	Contract signed by new market participant (import)	D = 1: 76 observations			
RENEGO	Extended / renegotiated contract	D = 1: 32 observations			
EU_post98	Contract with deliveries to Europe signed 1999–2006	D = 1: 57 observations			
C_US_UK	Deliveries for US or UK market	D = 1: 31 observations			
P_Oceania	Production in Oceania	D = 1: 85 observations			
P_Africa	Production in Africa	D = 1: 50 observations			
P_Russia	Production in Eurasia (Russia)	D = 1: 36 observations			
P_Europe	Production in Europe	D = 1: 79 observations			
P_ME	Production in Middle East	D = 1: 47 observations			

including Azerbaijan and Turkmenistan (the base case is Trinidad and Tobago and US-Alaska). The largest number of contracts for one exporting country that we cover is for Norway (45 contracts), followed by the Soviet Union/Russia (28 contracts), Algeria (27 contracts), the United Kingdom (10 contracts), and the Netherlands (9 contracts). The focus of our analysis is on contracts and market participants importing natural gas. The debate on an institutional level (such as creating an internal market in the EU) acknowledges the restricted control over producing countries, mostly in complex external relations.

The data include the date of contract signature and the starting and ending dates of deliveries, which also defines the contract duration (variable **CD**, see Table 1). **TVol** is the total contracted volume in billion cubic meters (bcm). There is a wide dispersion within both variables: the shortest contract duration is only two years (EdF Trading and Statoil, 2003), whereas the longest contract duration is 36 years (Norwegian export contracts from the Troll field, 1986). Contracted volumes vary too, between an annual volume of 0.3 bcm for a small LNG delivery and 360 bcm in one of the first long-term contracts concluded in the early days of the emerging industry. Higher volumes agreed upon in the contract imply a foresight with respect to income streams for investing parties. Therefore, we expect a positive relation between contracted total volumes and contract duration.

We are interested in the duration of long-term contracts (**CD**) and how the changing institutional framework, the maturity of energy markets, and overall market developments affect contract duration. Therefore we have defined additional variables that characterize different types of contracts:

- The variable “PROJECT” is a dummy variable that distinguishes contracts related to investments in a concrete project from other, more general contracts. Therefore, the dummy takes a value of one for asset-specific investments, such as the initial exploration of the Troll fields in Norway, the construction of an Interconnector pipeline, or a capacity extension at an LNG terminal. We expect a positive relation between the variable PROJECT and contract duration mainly driven by new, highly asset-specific infrastructure investments in the early days of the industry;
- Another dummy variable “ENTRANT” distinguishes importing incumbent companies that have been traditionally active in the natural gas market, from new importing market entrants. These new market participants can be electricity producers that are engaging in natural gas-based power generation, oil companies that are diversifying their business, or trading companies. Given the fact that these new market entrants are entering at later periods and thus engage in less asset-specific deals, we expect the coefficient of the ENTRANT-variable to be negative;
- Several contracts signed in early stages of the industry have been extended subsequently. To distinguish between “first-time” contracts and extensions/renewals we define a dummy variable (“RENEGO”). Since contract updates are less likely to be linked to significant start-up investments using existing routes, and the markets generally become more flexible over time, we expect contract duration to be negatively related to this variable;
- The restructuring of European markets for natural gas has brought about substantial changes in the industry. We identify all contracts with deliveries to Europe since the first EU Directive in 1998 (“EU_post98”) in order to investigate potential effects of the policy change.⁴ Given the experience of competitive markets in the U.S. and UK where contracts have substantially shorter durations, we expect a negative relation between sector restructuring and contract duration in our analysis.
- A generalized expectation of producing countries behavior is ambitious. On the one hand producers should have recovered their initial investments indicating a decreasing duration of contracts. On the other hand, import dependence of contract partners could induce strategic behavior of exporters. However, we expect a negative relationship between contract duration and exports to competitive markets (C_US_UK).

In all estimations we explain the dependent variable contract duration (CD) by the independent variables described above. We estimate two specifications of our model, allowing explanatory and dependent variables to enter in levels as well as log-levels as follows:⁵

⁴ Deregulation of natural gas markets and the creation of an internal competitive European market are the focus of this policy.

⁵ Joskow (1987) expects a diminishing effect of quantity as these increase, and a nonlinear relationship between the variables.

$$\begin{aligned}
 CD = & c + \beta_1 TVol + \beta_2 PROJECT + \beta_3 ENTRANT + \beta_4 RENEGO \\
 & + \beta_5 EU_post98 + \beta_6 C_US_UK + \beta_7 P_Africa + \beta_8 P_Eurasia \\
 & + \beta_9 P_Russia + \beta_{10} P_ME + \beta_{11} P_Oceania + \varepsilon
 \end{aligned} \tag{1}$$

$$\begin{aligned}
 \log(CD) = & c + \beta_1 \log(TVol) + \beta_2 PROJECT + \beta_3 ENTRANT + \beta_4 EU_post98 \\
 & + \beta_5 C_US_UK + \beta_6 RENEGO + \beta_7 P_Africa + \beta_8 P_Russia \\
 & + \beta_9 P_Europe + \beta_{10} P_ME + \beta_{11} P_Oceania + \varepsilon
 \end{aligned} \tag{2}$$

Employing logarithms of qualitative variables eases the potential issue of non-normally distributed error terms. Potential limitations due to sample truncation to a lower bound of 2 are taken into account by running maximum likelihood estimation for identical specifications.⁶ The hypotheses derived in the previous section suggest that we expect the following signs of the coefficients of the right-hand variables:

- positive: PROJECT (specificity of investment tied to contract) and TVol (income streams to cover upfront investment)
- negative: ENTRANT (contracts are less specific), RENEGO (no start-up investment), EU-post98 (experience from the US and UK), and C_US_UK (deliveries into mature markets)

4 Results

Table 2 presents the results of the OLS regression for equations (1) and (2) including White error correction to the data. Both model specifications yield the expected signs on the coefficients for the key variables and their R^2 respective adjusted R^2 -values are satisfactory. We first look at the results of the two hypotheses postulated above, and then move on to other interesting results:

H₁: We find that contract duration is indeed negatively related with the variables representing market restructuring: contracts signed for deliveries to the restructured markets of the U.S. or the UK are on average 2.4 years shorter than the others. Also, the restructuring directive of the EU had a significant impact in reducing contract durations after 1998 (−1.5 years). Clearly, long-term contracts tend to be shorter in natural gas markets that are moving to a more competitive institutional setting;

H₂: We can also confirm the hypothesis of a positive relation between the contract duration and the asset-specificity of the investments linked to a particular contract: Contracts that involve asset-specific investments are on average 3 years longer than others (variable “PROJECT”, 1% significance level). A similar interpretation can be given to the negative sign of the variable on renegotiated contracts (“RENEGO”): Contract renewals generally do not imply specific investments such as in the initial contract period, so it is normal that they are shorter (here about four years).

⁶ The result of the maximum likelihood estimations does not change the following results; they are available from the authors upon request.

Table 2 Estimation results

Specification	(1) (level)	(2) (log)
c	20.54*** (0.0000)	2.61*** (0.0000)
TVol	0.04*** (0.0000)	0.16*** (0.0000)
PROJECT	3.09*** (0.0000)	0.16*** (0.0002)
ENTRANT	-3.09*** (0.0001)	-0.19*** (0.0004)
RENEGO	-4.36*** (0.0000)	-0.29*** (0.0000)
EU_post98	-1.50** (0.0416)	-0.12** (0.0170)
C_US_UK	-2.42** (0.0502)	-0.12 (0.1218)
P_Africa	-2.39** (0.0525)	-0.15* (0.0526)
P_Eurasia	-3.86*** (0.0014)	-0.25*** (0.0007)
P_Europe	-2.85** (0.0303)	-0.25*** (0.0016)
P_ME	-2.93** (0.0178)	-0.21** (0.0107)
P_Oceania	-3.15*** (0.0067)	-0.15** (0.0430)
R ²	0.326	0.387
Adj. R ²	0.301	0.365

Reported are estimated coefficients and p-values.

***, **, * indicate significance at 1%, 5%, and 10% levels

Contract duration is positively related to the total volume covered by the contract (TVol), which is not surprising. We also find that market entrants (ENTRANT) sign contracts that are on average three years shorter than those of incumbents. This confirms the hypothesis that long-term relations are mainly needed in the early stages of industry development, whereas later contracts with new players can be structured more flexibly.

5 Conclusions

In this paper, we have applied transaction cost theory to interpret the dynamics of long-term contracts in the international natural gas industry. Whereas long-term contracts in the literature have been identified as a specific form of upstream-downstream relations, the determinants of the dynamics of long-term contracts have been less studied. The natural gas industry is very dynamic, albeit involving large investments, and has undergone significant regulatory reforms during the last decades. From being a “boring” industry with mainly monopolistic market structures, it has become a diverse and market-oriented industry with a range of organizational forms, among which are long-term contracts.

Based on a technical and institutional analysis of the natural gas industry we have developed two main hypotheses for the empirical test. Using an extensive database of 311 long-term contracts world-wide, we find empirical support for both hypotheses: i) as the industry moves towards more market-oriented coordination mechanisms, driven by regulatory attempts to restructure the industry and to foster competition, the duration of long-term contracts has been significantly reduced. The need to back up large-scale kick-off investments into natural gas production, transportation, and distribution infrastructure by long-term contracts diminishes as the industry is maturing; ii) we also confirm the traditional hypothesis of transaction cost economics that if highly asset-specific investments are at stake, the average contract duration is longer in order to back-up these investments.

We also found empirical evidence on additional issues, much as impact of contract renegotiation on contract length and the effect of certain destination countries on contract length. We were not able to study the evolution of price indexation clauses, which is an important indicator of the state of institutional reform that a country or a region is in. This and the dynamics of long-term contracting in similar industries, such as iron ore or uranium, should be the focus of further research. One might also try to separate the technical from the institutional effects in the duration of contracts.

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