

Long-Term Contracts for Natural Gas Supply – An Empirical Analysis

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Abstract

In this paper, we analyze the determinants of contract duration in a large number of natural gas contracts. We test the impact of different institutional and structural variables on the duration of contracts. We find that in general, contract duration decreases as the market structure of the industry develops from monopolistic to more competitive regimes. Our main finding is that contracts that are linked to an asset-specific investment are on average 7 years longer than the others; however, their duration decreases with liberalization as well.

Keywords: long-term contracts, asset-specificity, natural gas

JEL-Codes: L22, L95, Q41

1 Introduction

Long term contracts are back on the research and policy agenda. The issue of long-term contracts as an intermediate organizational form somewhere in between vertical integration and short-term, market-based trading in itself is a regular topic in institutional economics and contract theory. Yet empirical work on the determinants of long-term contracts evolved mainly in the 1980s (e.g. Joskow, 1987) in the wake of liberalization and globalization of commodity markets (such as oil, natural gas, non-ferrous metals, steel, etc.). This debate, which had somewhat abated in the 1990s, is now back in full swing, driven by theoretical developments in institutional and contract theory, but also by increasing concerns about reduced security of supply and skyrocketing short-term prices of these commodities, the most drastic being the unexpected surge in oil prices.

The interpretation of long-term contracts also depends to a certain degree on subjective assessments, and sometimes on pure interests: thus, adherents of market competition are generally less enthusiastic about the (re-) emergence of long-term contracts, as these reduce the scope for short-term competition. On the other hand, industry and a large part of policymakers defend the (often collusive) nature of long-term contracts with its positive impact on investment decisions. Competition authorities therefore have a difficult time when assessing the total impact of long-term contracts on social welfare.

This paper provides an empirical assessment of the changing nature of long-term contracts in a commodity sector that has undergone drastic structural change during the last decades: natural gas. Natural gas is not only a rapidly expanding, global business due to the environmental-friendly and flexible uses it offers, but is also an under-researched sector since the mid- and late 1980s. The paper analyzes the development of long-term contracts in liberalizing natural gas markets world-wide, with a particular focus on the determinants of the duration of contracts under changing technical, economic, and institutional conditions. Our hypothesis, derived from theoretical work and more recent empirical analysis, is that the move from a monopoly industry to more competitive market structures implies that long-term contracts lose some of their importance, and that they are likely to play a considerable role (only) when large-scale, asset-specific investment decisions are at stake.

The paper is structured in the following way: the next section provides a comprehensive review of the literature on long-term contracts in the natural gas and other sectors, both from a theoretical and an empirical perspective. Section 3 describes the structural changes ongoing in the natural gas industry, both from a technical, an institutional, and an economic perspective. From there, we derive the main hypotheses to be tested in Section 4 (“Data, Model Specification and Results”). Based on a unique dataset of 317 long-term natural gas contracts, we test the impact of structural and institutional variables on the duration of these contracts. Amongst other things, we find that the contracts duration decreases significantly as natural gas markets become more competitive, and that the volume of yearly

contracted gas is positively correlated with the contract length. Our main result is that contracts related to a significant asset-specific investment are on average several years longer than those where less significant investment issues are at stake. The last section concludes.

2 Literature Survey

It has been widely recognized that long-term contracts are a way of minimizing transaction costs for two parties engaging in a commitment involving significant specific assets. Long-term contracts including requirement clauses, price indexation, liquidated damages, arbitration and other provisions have been identified as a means to overcome the “hold-up” problem without vertical integration. The hold-up problem is likely to arise when transaction-specific investments are required (Klein et. al (1978)). Indeed, asset-specific investments and uncertainty are the main contributing factors to a high level of transaction costs as defined by Williamson (1975, 1985), all of which explain requirements of alternative institutional arrangements as opposed to “simple” contracting (Williamson, 1983). As a theoretical response to transaction cost economics, the concept of incomplete contracts has been developed (Grossmann and Hart (1986), Hart and Moore (1988)). Both concepts are based on the assumption of opportunistic behavior by the agents whose rationality is bounded. However, as pointed out by Saussier (2000), the main difference of these concepts is the role of contracts: whereas in the incomplete contracting framework contracts minimize ex ante investments distortions, in the setting of transaction cost economics they provide sufficient investment incentives and inexpensive ex post renegotiation.

Research since Coase’s (1937) article has brought forward many amendments to institutional economics, but all contributors so far agree upon the fact that minimizing transaction costs depends on the degree of asset-specificity, on the level of uncertainty, and the frequency of transactions. Two parties wanting to engage in a supplier-buyer relationship have instruments of institutional arrangements available ranging from anonymous spot trading via long term contracting to vertical integration. As noted by Richter and Furubotn (1999), the lack of a consistent theoretical framework has lead to the development of a variety of methodologically related approaches which are partially overlapping, complementing and extending but also differentiating one another.

Long-term contracts in the energy sector have served as one of the earliest to provide empirical evidence of transaction cost theory. Joskow (1987, 1988) shows that the duration of contracts in the American coal industry is positively related to the level of asset-specificity. Crocker and Masten (1985) and Masten and Crocker (1988) were the first to empirically test the influence of different regulatory regimes in the US natural gas sector. They examine a sample of 245 American natural gas contracts with detailed information provided by the Energy Information Agency, and determine

changing regulatory environment and liberalization efforts as the main parameters of these contracts. Mulherin (1986) provides evidence that governmental regulation in the US (mainly the Public Utility Holding Company Act of 1935 and the Natural Gas Act of 1936) led to an increasing use of long-term contracts and take-or-pay provisions and price adjustments reducing the hold-up problem. Hubbard and Weiner (1986) analyze take-or-pay provisions of long-term gas supply contracts following deregulation of wellhead prices in the US. The sample of 884 natural gas contracts, collected by the Energy Information Administration in 1982, signed after the 1978 Natural Gas Policy Act reveals minor effects in mean take-or-pay requirements, in line with MacAvoy's (1962) observations. Doane and Spulber (1994) argue that open access to the transportation system reduces the potential for bilateral monopoly between pipeline owners and field producers and the related contractual holdup problem. Thus, transaction costs associated with assuring contractual performances will be reduced. The process of liberalization and market integration currently underway in Europe (excluding the UK) with the ambition to create a functioning internal market for electricity and natural gas already was completed 20 years ago in the US and some 10 years ago in the UK. Thus, the developments in these two countries serve as a benchmark for the developments to expect in continental Europe. Empirical evidence on the changing nature of long-term contracts in the US and the UK suggests an inverse relation between gas sector liberalization and contract length, although long-term contracts do not entirely disappear with market liberalization. In both countries, long-term contracts between gas producers and wholesale buyers have lost "market share". Average contract length has shortened significantly (to approximately 8-15 years instead of 20-25 years) (Neuhoff and Hirschhausen, 2005). In the US, the share of gas supplies through long-term contracts was reduced from about 100% to below 50%. Until 1991, the average contract volume fell from 1.27 bcm/a to 0.24 bcm/a (IEA, 1998). However, as gas demand picked up again in the late 1990s, industry found itself suddenly deprived of (moderately priced) gas supplies. Hence, in the year 2000 (and, notably, before the Californian energy crisis), prices rose significantly, and have remained high until today. It is expected that gas prices will remain high, whereas most large consumers are currently attempting to (re-)conclude long-term contracts, both for pipeline gas and for liquefied natural gas (LNG). In the UK, one observes a similar trend: a price drop in the first years after liberalization. Today, about 85% of gas delivered at the beach is covered by long-term contracts (IEA, 2004, 110). The most recent contracts contain a price indexation to the UK spot gas market, and no more ToP-obligation. A liquid spot market has developed.

The first quantitative analysis of developments in European long-term gas supply was provided by Neumann and Hirschhausen (2004). It was based on a dataset of long-term contracts concluded by European importers since 1985. The authors show that the length of take-or-pay contracts for gas supply to Europe has significantly decreased over the past two decades, which supposedly is driven in

large part by the move towards liberalization in the European Union. The results do not suggest the disappearance of long-term contracts for European gas supply; rather, it puts emphasis on required structural changes of these contracts adapting to a more competitive environment. In a theoretical paper, Neuhoff and Hirschhausen (2005) take the analysis a step further by accounting for different short-run and long-run demand elasticity. The analysis shows that for long-run demand elasticity significantly higher than short-run elasticities, producers prefer institutional arrangements allowing for long-term contracting.

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

During the last 25 years, natural gas markets world-wide went through significant structural changes, both in technical, institutional and economic terms. This section describes some of the changes that can be quantified and that will yield testable hypotheses for the quantitative analysis.

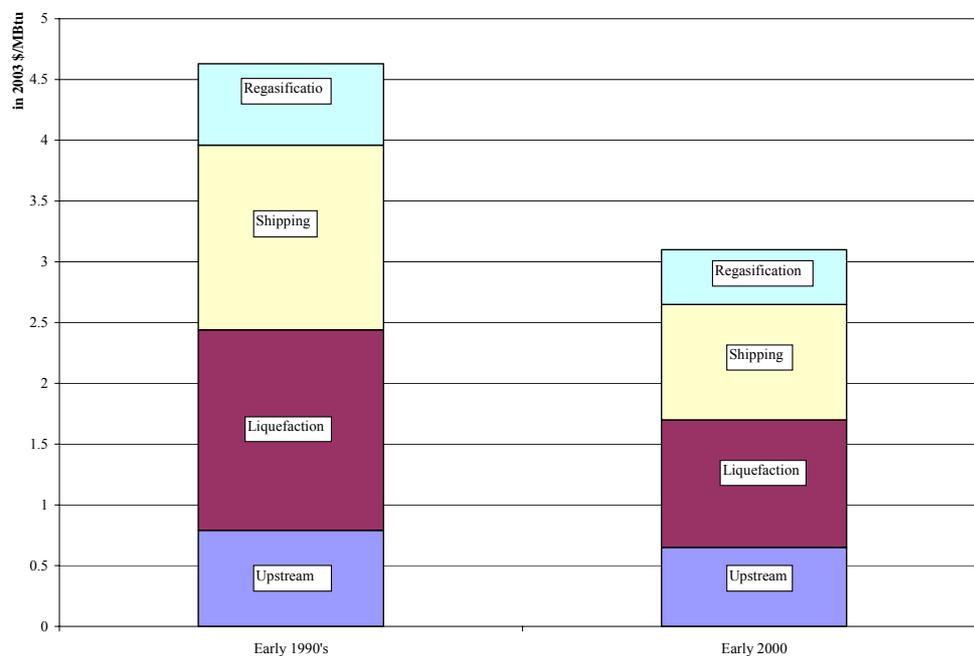
3.1 Decreasing capital intensity (in particular in the LNG chain)

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 diminishes. This is particularly the case for LNG, but it also holds 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\$). Figure 1 shows the composition of these costs, the reduction of which has different sources:

- Liquefaction is carried out in larger units than before. Standard size of a train was about 1 mtpa per year at the upsurge of LNG business and has now reached a capacity of 3.5 to 4 mtpa; plans for 7.8 mtpa trains exist in Qatar (ConocoPhillips and Bechtel, 2004);
- Likewise, shipping is carried out in larger LNG-vessels (140.000 to 145.000 cm today, 40.000 cm 15 years ago, 25.000 cm 40 years ago) that use more efficient motors; costs for construction of tankers in Asia have dropped from \$250 million to \$170 million for a standard 135.000 cm ship since some ten years ago (IEA, 2004);
- Downstream, regasification also benefits from scale economies mainly for storage (according to IEA (2004) tanks with storage capacity of 200.000 cm are the current optimal size) and using different technologies.

Decreasing investment intensity leads to lower risks in the industry, and should thus have a negative effect on contract duration

Figure 1: Decreasing capital intensity for LNG



Source: Jensen (2004), IEA (2004), EIA (2003)

3.2 Diminishing asset specificity of investment

Distinct from lower capital costs is the issue of the changing nature of the asset-specificity itself. In the “old days”, the emergence of international gas trade between large producers (such as Canada or Russia) and consumers (such as the US and Western Europe) required investments into the upstream natural gas fields, pipeline infrastructure, and a downstream distribution network. These investments were often project-specific, leading to a high asset-specificity and, subsequently the well known issues of quasi-rent negotiations, which were often resolved by the use of long-term contracts.

Since these days, market structures up-, mid-, and downstream have changed, leading to a significant reduction of asset-specificity:

- Upstream, contracts are no longer field-specific, but related to the global exports of a country or a producer. Thus, investments are no longer contract-specific, i.e. a given field can be used to serve a variety of contracts. These developments are mirrored in the abatement of the destination clause in European contracts. The development of a large number of trading companies also diminishes

the asset-specificity, since the loss of having to move from the first-best match to the second-best match (i.e. another trader) is no longer large¹;

- Midstream, a lot of the necessary long-distance pipeline connections have been established. Thus, new projects require “only” a low portion of capacity expansion, either via an increasing number of compressor stations, or an additional trunk line. This investment is no longer highly asset-specific;
- Similarly, the downstream investments in distribution infrastructure is no longer required to be built from scratch, but only to be extended gradually.

The decreasing asset-specificity of natural gas trade related investment implies a reduced reliance on long-term contracts to resolve potential hold-up conflicts. In our view, this would suggest -ceteris paribus- lower contract duration over time.

3.3 Development of spot markets

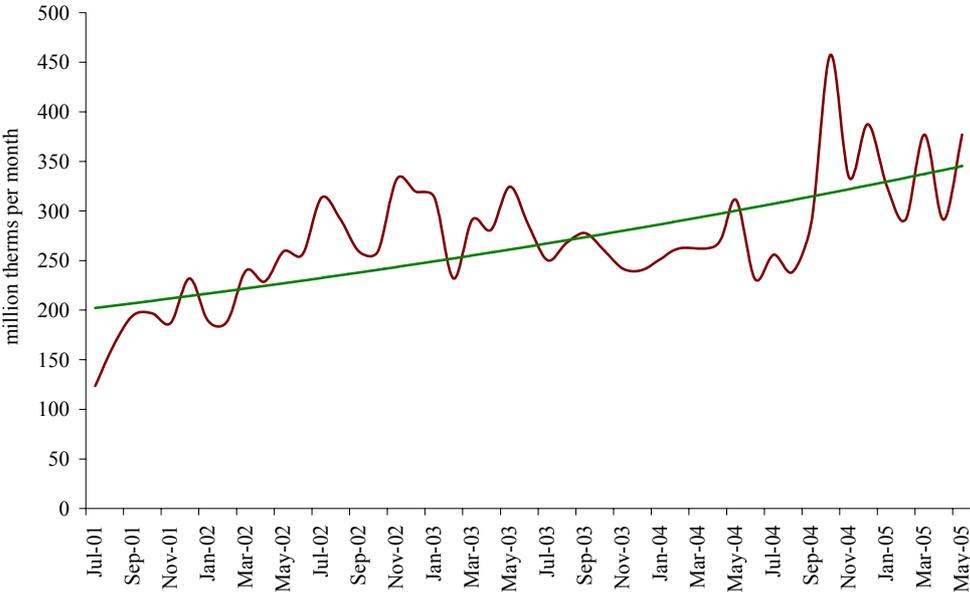
Major contributions to a functioning stand-alone gas market are expected to stem from the maturity of spot markets. Spot markets are trading places in which a commodity is bought or sold for immediate delivery or delivery in the very near future. International experience shows that those trading centres are likely to emerge at locations where several sources of supply and demand interconnect, often including a landing for LNG. Examples are the Henry Hub (USA), Zeebrugge (Belgium), or NBP (UK). Determining factors for the success of trading places are participation of traders and the institutional framework surrounding the business. Liberalized markets generate spare quantities unsold under long-term contracts, and an increasing number of players trading at short notice. Furthermore, a sound regulatory system ensuring planning viability for industry and efficient use of the pipeline network are required. Finally, regulated third party access to the network, favourably implementing an entry-exit tariff system, are requested. Market places require suppliers and buyers willing to trade at prices set defined by supply and demand. Existing and newly signed long-term contracts will have to undergo significant changes in order to provide additional quantities of gas to be traded at spot markets. A common instrument encouraging and simplifying the development of notional trading places is the chosen type of an entry-exit tariff system for the network.

Spot markets are becoming more liquid: trade at Zeebrugge in Belgium, the Title Transfer Facility in the Netherlands and other Continental European trading places is increasing, thus following the developments at the NBP and therefore reducing uncertainty in short term trade to a certain extent.

¹ The changing nature of LNG trade towards more spot and short-term trade without signing long-term agreements before investing in regasification terminals (Hartley and Brito (2002)) clearly point towards a lower asset-specificity of these projects.

Standardization of products and introduction of financial instruments such as options and forward futures provide appropriate tools for managing price risks in a “new” environment.

Figure 1: Monthly traded volume at NBP



Source: APX Gas Ltd.

Integration of NBP and Henry Hub via expectations on future prices coupled with an intensification of trade at the TTF and Zeebrugge will ensure investments incentives as well as a sound basis for increasing short-term trade. Moreover, implementation of a favourable regulatory environment does not only improve planning certainty for industry, but also fosters the development of further trading centres. Uncertainty in natural gas trade is diminishing with the rapid developments of spot markets and with increasing liquidity on these markets (e.g. NBP in the UK, Zeebrugge in Belgium, TTF in the Netherlands, PEG in France, PSV in Italy, Baumgarten in Austria).

The share of short term LNG trades in international gas trade has grown steadily over the last two decades.² Thus, with an increasing spot trade we should observe a reduction in long-term contract duration.

3.4 Increased number of market participants

Currently, we observe an increasing number of market participants in several segments of the value chain:

² Jensen (2005) refers to 11.2% spot trade in total LNG movements in 2004. However, up to now, spot trading has only had little effect on the market from which cargoes have been diverted. As swaps avoid cross-shipping thus substantially reducing transportation cost they are prone to be exercised more often in the LNG trade.

- Upstream, the number of natural gas producers and exporters has increased during the last decade. Countries like Nigeria, Trinidad, Libya and Egypt, and even Australia have joined the incumbents such as Russia; thus competition upstream has increased
- Downstream, at the level of wholesale trading, one also observes a move away from monopolistic structures, a variety of market entrants such as multi-utility companies and power plants are engaging in the market. This is particularly the case in Europe after gradual liberalization set in the late 1990s.³

Realized cost reductions, especially in the LNG business, have mainly attracted global oil players integrating downstream. In a growing natural gas market, characterized by more flexibility in contract duration, volumes, and alternative re-selling of received LNG the number of market participants increases substantially. New entrants, mainly electricity companies aim at a direct supply of natural gas thus benefiting from more supply security in times of increasing demand.

Using a traditional microeconomic search model, Hartley and Brito (2002) have shown that an increasing number of market participants in natural gas trade leads to more short-term trade, as compared to the old regime of bilateral monopolies. Along these lines, we expect that the increasing number of natural gas producers and wholesale traders enhances contracting opportunities other than long-term contracts and leads to a reduction in contract duration.

Formally, the changing nature of contracts in international gas trade can be explained by a changing level of transaction costs triggering changes in the institutional organization of the sector. According to standard theory, transaction costs are expected to increase with growing asset-specificity and uncertainty, and to decrease with the frequency of transactions. The developments as outlined above should therefore contribute significantly to the reduction of transaction costs. This in turn reduces the need for “traditional“ long-term contracts and hence, explains the observable reduction in contract duration. Summarizing, the following reasons and their potential impact on transaction costs have been identified as the main structural changes currently taking place:

- increasing spot trade on liquid markets, thus reduced frequency of transactions with one partner (-)
- reduction of uncertainty (due to growing demand, institutional framework) (-)
- decreasing asset- specificity (-)

³ The number of players differs significantly in European member states. Whereas only 40% of available gas is controlled by the largest company in Spain this share amounts to 91% in France (European Commission, 2005). Positive developments have mainly taken place in Southern Europe (Spain, Italy) where this market share has come down from 75% to more acceptable levels.

4 Model Specification and Results

4.1 Data

Empirical research in international natural gas trade is heavily restricted due to data availability. Different to the US, where a list of signed contracts and respective information on price provisions, take obligations and several adjustment parameters as of 1981 is available, there seems to be no better secret kept in European trade than which company is supplying natural gas under which conditions. Therefore, the data used in this analysis has been collected from several public available sources and partly verified through expert interviews. Detailed information is available on the date of contract signature, and for a large part on the starting and ending date of deliveries and contracted volumes (annual or total).⁴ Recently signed contracts linking the price for natural gas in these contracts to power pool prices, natural gas spot market prices or mixtures of these have been extensively exploited by trading press as if to document the dawn of a new era. The same applies to LNG contracts where segmented evidence on negotiated fob-pricing is available.

Overall, we have identified 317 contracts with a duration exceeding one year signed between 1963 and 2005. For the remainder, only contracts signed since 1980 are included into our analysis. This decision is based on an apparent lack of information for contract signatures in the 1970s. A summary of characteristics of the sample is provided in Table 1.

Table 1: Summary statistics

	All	Europe
Observations	252	132
Contract duration (years)		
Mean	19.30	19.01
Max.	39	39
Min.	2	2
Standard Deviation	6.73	8.22
Skewness	-0,07	0.16
Kurtosis	3.45	2.67
Yearly contracted volume (bcm)		
Mean	2.29	2.83
Max.	16.00	16.00
Min.	0.03	0.15
Standard Deviation	2.42	2.82
Skewness	2.16	1.92
Kurtosis	9.31	7.57

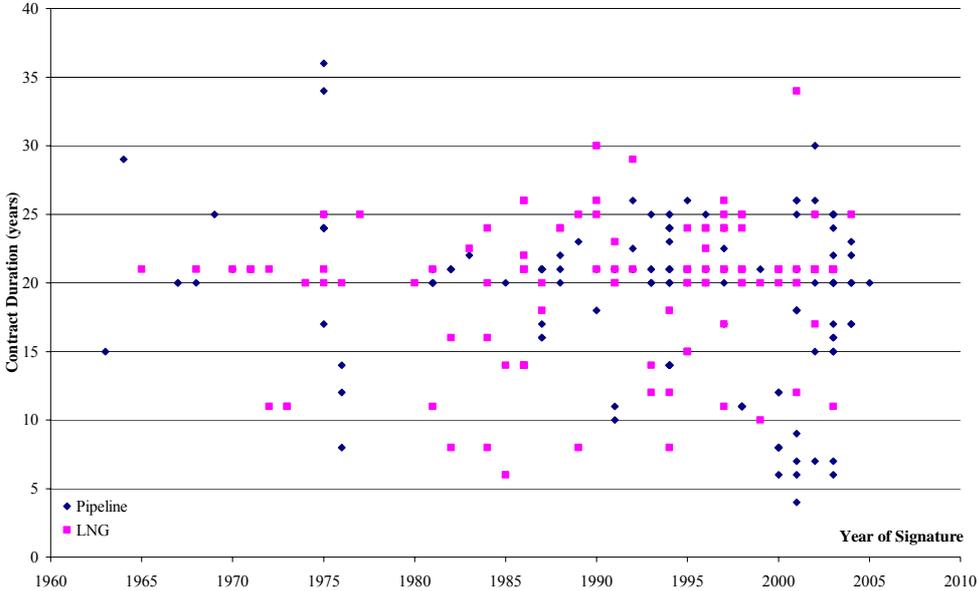
⁴ We have no information about price settings in these long-term contracts whereas it seems to be common knowledge that those are indexed to the substitute fuel oil through a variety of formulas. It is also interesting to note that neither the national governments nor the European Commission have verifiable information on European gas supply contracts. However, with the commitment of the European Commission to "..., within five years of the entry into force of this Directive, submit a

While we cover natural gas contracts worldwide, the dataset provides particularly accurate information on European imports, as it includes 23 contracts with Russia, 42 with Norway, 10 with Algeria, and 11 and 9 with the UK and the Netherlands respectively.⁵

European LNG importing contracts include a variety of imports to France, Spain, Belgium, Portugal and Italy. Smallest volumes of natural gas were agreed upon by traditional gas importing and exporting companies of the Netherlands and Norway in the year 1975 with respect to pipeline gas, and between Japan and Australia for LNG in 1994. However, the trading branch of a market entrant, Electricité de France, added the shortest pipeline importing contract when signing an agreement with Statoil of Norway to deliver 0.9 bcm for two years to France in 2003. The contracts with the longest duration originate in deals between traditional monopolistic importing and exporting companies.

A large share of the sample set including all contracts is represented by trade in the Asian-Pacific region. The dependency on LNG imports mainly from Malaysia, Indonesia and Australia has been neatly documented. Prices for natural gas imports in Asia are known to be linked to the JCC (Japanese Crude Cocktail, the average of Japanese crude import prices) and signed for long time periods. Recent developments indicate the willingness to introduce more competitive trading. However, this will only be implemented when the Asian electricity sectors have been liberalized.

Figure 4: European pipeline and LNG contracts



Source: own data

review report on the experience gained from the application of this Article” (2003/55/EC, Article 27(6) on take-or-pay contracts) raises the prospects of more transparency by 2008.

⁵ According to experts 10 to 12 long-term contracts a year are signed in Europe.

4.2 Methodology and Model

We are interested in the duration of signed long-term contracts (CD) and ask how the changing institutional framework, maturity of energy markets and overall market developments effect contract duration.

- Contract length should be inversely related to the date of contract signature (YoS);
- As gas producers regularly argue that long-term contracts are required to ensure reasonable long-term rents in order to cover up-front investments we expect a positive relation between annual contracted volumes (YVol) and contract duration;
- The variable of major interest is called PROJECT and defined as a dummy variable. It will take the value of one if the signed contract is dedicated to a certain greenfield project (such as the exploration of the TROLL field, the construction of the IUK) or a capacity extension at a LNG terminal exhibiting a high level of asset-specificity;
- Spot markets provide a relatively efficient mechanism with regard to transaction costs, whereas bilateral contracts implicate higher transaction costs than financial instruments traded on market places. Therefore, we include the share of LNG spot trade in total traded volumes of liquefied natural gas (SPOT) in the respective year into our analysis expecting a negative relation with the dependent variable;
- Major contributions to competition are expected to be made by new market entrants. This might either be power producers, oil companies or new gas companies aiming at minimizing the costs of negotiating, enhancing and controlling agreements. Therefore, the dummy variable TRAD for “traditional” market participants is defined in order to distinguish the market incumbent from market entrants;
- In Europe, a number of efforts have been undertaken to introduce competition to electricity and natural gas markets. The first major change in legislation (LEG, defined as a dummy variable) of the year 1998 is expected to have a diminishing influence on contract duration;
- Exploration of natural gas reserves mainly in South America, Middle East, Europe, and North Africa (ORIGIN) requires transportation over long-distance and many transit countries. Political and economic instability in some of these regions might negatively influence contract duration.

Using a similar approach as Joskow (1987), we estimate three specifications allowing explanatory and dependent variables to enter in levels as well as log-levels. The specifications are defined as follows:

$$\text{Contract Duration}_i = c_i + \beta_1 \text{YoS}_i + \beta_2 \text{YVol}_i + \beta_3 \text{PROJECT}_i + \beta_4 \text{SPOT}_i + \beta_5 \text{TRAD}_i + \beta_6 \text{LEG}_i + \beta_7 \text{ORIGIN}_i + \varepsilon_i \quad (1)$$

$$\text{Contract Duration}_i = c_i + \beta_1 \log(\text{YoS})_i + \beta_2 \log(\text{YVol})_i + \beta_3 \text{PROJECT}_i + \beta_4 \text{SPOT}_i + \beta_5 \text{TRAD}_i + \beta_6 \text{LEG}_i + \beta_7 \text{ORIGIN}_i + \varepsilon_i \quad (2)$$

$$\log(\text{Contract Duration}_i) = c_i + \beta_1 \log(\text{YoS})_i + \beta_2 \log(\text{YVol})_i + \beta_3 \text{PROJECT}_i + \beta_4 \text{SPOT}_i + \beta_5 \text{TRAD}_i + \beta_6 \text{LEG}_i + \beta_7 \text{ORIGIN}_i + \varepsilon_i \quad (3)$$

If we assume standard properties of error terms in equations (1) to (3), OLS will provide best linear unbiased estimates. However, as pointed out by Sykuta (2005) and Masten and Saussier (2005) in an analysis of empirical work in new institutional economics, we might encounter a number of challenges regarding data which imply that the standard OLS procedure will produce a regression that is a biased estimate of the true slope. In the case of contracts, there are three limitations in using OLS techniques: First, values of the variable duration are limited to a lower bound of zero, thus effecting the distribution of error terms. Second, results may be biased due to over-presentation by longer-term agreements (see Masten and Saussier, 2002, and Maddala 1983). This can be taking account of when using maximum likelihood estimation techniques as done by Joskow (1987) and Crocker and Masten (1988). Finally, heteroskedasticity may arise due to long-term contracts usually occurring in clusters at discrete intervals of five or ten years, compared to short and spot-term trading. To control for endogeneity in our specifications, we use standard two-stage least squares (2SLS) estimations to identify the appropriate regression specification. Furthermore, due to sample truncation, maximum likelihood estimation procedure is applied to our data set with regard to European contracts on the one and all agreements on the other hand.

4.3 Estimation results

Results of estimation specifications considering the sample of European contracts only are presented in Table 2. In a first step, we identify the variables to include into our analysis. All the estimated coefficients from the 2SLS as well as the MLE approach confirm our anticipation at a 1% significance level. Over time, contract duration is diminishing and higher annually contracted volumes lead to longer contract duration. What is most important is the fact that the main hypothesis of a positive relation between asset-specificity and contract duration is confirmed at a highly significant level. Contracts that have been tied to the development of infrastructure are on average almost 7 years longer than others.⁶ This indicates the similarity to developments in the US where mature infrastructure and market environment have led to shorter average contract durations in the range of 8 to 15 years. Since the regional sourcing of natural gas does not significantly impact contract duration, we conclude that

⁶ Since the third representation allows both regressor and regressand to enter the specification in loglevels, estimated coefficients prevail on a much lower level. However, the predicted negative relationship is still confirmed at significant levels when using 2SLS as well as ML estimation procedures.

the argument of investment incentives remains the driving force for the use of long-term contracts in European imports of natural gas.

Table 2: Estimation results for Europe

	2SLS			ML		
	(1)	(2)	(3)	(1)	(2)	(3)
C	1305,588*** 163,365	10185,96*** 1235,164	630,286*** 87,111	1316,035*** 188,86	10267,06*** 1408,673	616,364*** 104,678
YoS	-0,646*** 0,082	-1338,297*** 162,576	-82,590*** 11,468	-0,652*** 0,095	-1348,954*** 185,340	-80,755*** 13,771
YVol	0,904*** 0,169	2,830*** 0,493	0,176*** 0,035	0,925*** 0,217	2,916*** 0,565	0,174*** 0,040
PROJECT	6,799*** 1,195	6,282*** 1,167	0,373*** 0,065	6,981*** 1,424	6,528*** 1,393	0,382*** 0,122
AFRICA	-1,769 1,380	-1,806 1,364	-0,157 0,116	-2,099 1,733	-2,194 1,709	-0,177* 0,099
EUROPE	-1,734 1,202	-1,641 1,167	-0,138 0,085	-2,046 1,556	-2,000 1,516	-0,157 0,102
adj. R ²	0,460	0,508	0,415	0,450	0,481	0,405
LogLik.				-421,194	-417,713	-69,525

Reported are estimated coefficients with respective standard errors

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

In analogy to the European sample we proceed with our investigation of all contracts. The results are similar and presented in Table 3. Estimated coefficients reveal the predicted signs at high significance levels. The variable of main interest, PROJECT, has lost some of its powerful impact but still confirms the importance of asset-specificity on contract duration. Somehow surprising, the share of LNG spot trade in global LNG trade exhibits positive coefficients, thus prolonging contract duration. This might be explained by the lack of precise data availability of the share of spot trading of pipeline and LNG movements. However, an increasing number of market participants on the exporting as well as on the importing side might have contributed to decreasing costs of searching contracting partners. Hence, duration of contracts was shorter for importers not being a market incumbent. Deliveries over long-distances via ships (AMERICAS, MIDDLE EAST) and pipelines (MIDDLE EAST) from and via a number of “hot spots” encourages the use of long-term contracts as opposed to imports for instance within Europe. Efforts of changes in the institutional and legislative framework have endorsed decreasing contract duration. Contracts signed at the end of the last millennium and the beginning of the new, respectively, are on average 3 to 4 years shorter than those signed in the “old world”.

Table 3: Estimation results for all contracts

	2SLS			ML		
	(1)	(2)	(3)	(1)	(2)	(3)
C	105,165*** 203,015	7903,591*** 1593,135	466,339*** 99,978	990,566*** 222,714	7504,789*** 1653,989	439,979*** 122,278

YoS	-0,521*** 0,102	-1038,044*** 209,748	-61,016*** 13,164	-0,489*** 0,112	-985,531*** 217,761	-57,545*** 16,097
YVol	0,789*** 0,149	1,822*** 0,310	0,105*** 0,020	0,807*** 0,154	1,877*** 0,359	0,107*** 0,026
PROJECT	2,899*** 0,813	2,992*** 0,798	0,182*** 0,049	2,809*** 0,795	2,907*** 0,787	0,176*** 0,062
SPOT	0,897*** 0,231	1,003*** 0,241	0,063*** 0,019	0,695** 0,328	0,836** 0,352	0,053** 0,022
TRAD	-2,183*** 0,727	-2,406*** 0,732	-0,129** 0,052	-2,047** 0,868	-2,283*** 0,842	-0,122** 0,054
LEG	-4,135*** 1,436	-5,000*** 1,428	-0,369*** 0,106	-3,246* 1,966	-4,301* 2,121	-0,324** 0,136
EUROPE	-0,589 0,989	-0,293 0,962	-0,092 0,064	-0,519 0,798	-0,227 0,805	-0,088 0,056
AMERICAS	4,319*** 1,545	4,256*** 1,561	0,255*** 0,090	4,445** 2,312	4,383* 2,263	0,259 0,184
MIDDLE EAST	3,941*** 0,962	3,570*** 0,967	0,207*** 0,070	3,748*** 1,329	3,818*** 1,256	0,219*** 0,079
adj. R2	0,305	0,312	0,269	0,324	0,305	0,264
Log Lik.				-787,638	-786,075	-110,029

Reported are estimated coefficients with respective standard errors

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

5 Conclusion

Energy markets remain a fruitful field of institutional economic analysis. Deregulation of North American markets for natural gas has been followed immediately by econometric analyses. New institutional economics identified asset-specificity, frequency and market uncertainty as the key drivers for transaction costs. Events in the US were followed by significant changes in trading and contracting patterns. Today, most of the gas on the US-American and British gas markets is sold under short – and medium-term contracts, spot trade at a diversity of market places has reached a mature level, spot markets are liquid and financial instruments with a depth of up to 9 years have evolved. Similar to these events, European markets are today, 20 years later, undergoing significant changes. Breaking up of monopolistic market structures, introduction of regulated third party access to infrastructure, decreasing indigenous production, and the growing importance of LNG in the supply mix cause increasing spot activities, entrance of new market participants, and multi-sourcing of supplies.

We have analyzed the development of long-term supply contracts under different institutional regimes. Long-term contracts are generally considered as a measure to overcome the hold-up problem albeit assuring efficient investments in infrastructure. However, with a growing maturity of the existing transporting infrastructure and increasing competition, theory predicts a diminishing importance of long-term contracts on investment incentives. Using an extensive database of 317 contracts, we show that contract duration is diminishing over time, and is positively related to annually contracted

volumes. Contracts that have been signed in combination with exploration of new resources or building of new infrastructure are on average seven years longer in duration in Europe and almost three years for all contracts.

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