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Can LNG increase competitiveness in the natural gas market?

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ABSTRACT

The article develops an oligopoly model to analyze the potential role of LNG in the liberalization of gas market. The assumptions of the model and its results are then discussed using the forecasts of gas demand and production for the next two or three decades.

1. Introduction

The potential role of the liquefied natural gas (LNG hereafter) chain in facilitating the actual liberalization of gas market and the security of its supply has been deeply debated by natural gas experts. Indeed, import through LNG chain, that is, through the employment of LNG tankers for gas transportation, presents an undeniable advantage: contrary to what happens with gas transported via pipeline, LNG does not imply an indissoluble physical tie between producer and buyer (Chernyavs'ka and Dorigoni, 2002). In other words, a pipeline is a very specific investment, where the greater is the devaluation or the switching costs deriving from an alternative use, the greater the specificity of the asset. In the case of a pipeline, the degree of specificity is maximum (more precisely, the degree of "site specificity" is maximum, Williamson, 1985): in fact, durable investments in pipeline construction are made in order to support specific transactions, and their opportunity cost is much lower than those deriving from the best alternative uses. In these cases, the importance of the specific identity of the transaction counterparts is crucial and, consequently, great importance is given to the continuity of the contractual relation, so that contractual and organizational safeguards are often provided. In particular, these transactions take the form, for the natural gas market, of long-term agreements with minimum offtake requirements (take or pay clauses), designed to safeguard counterparts from ex-post contractual opportunism (hold-up problem), that is really likely in these circumstances. Such contracts definitely contribute to the "cartelization" of the market, hindering competition.

Unlike investments in pipelines, those in the LNG chain present a much lower degree of specificity: in fact, even though the construction of a regasification plant is generally tied to the stipulation of a long-term agreement (with take or pay clause), LNG chain costs have significantly decreased over time, thanks to technological innovation (Oil&Gas Journal 2006). Moreover, it is getting increasingly common that part of the plant capacity is made available for spot transactions (in some countries this is a regulatory requirement, CEER, 2006). What's more, once the contract is expired and the investment is sunk, the importer may satisfy his gas supply needs buying from the most convenient supplier. Beside theoretical considerations, it is worth mentioning that, given the lack of capacity on international import pipelines, for the time being LNG seems to represent the sole possibility for new competitors to enter the market. Long term import take or pay contracts held by gas incumbents play a pre-emption activity on transit pipelines and access cannot be granted to third parties. Moreover, LNG could enable traditional European importers to widen their gas suppliers' portfolio, also considering that some producing countries (i.e. stranded gas) can be reached only via sea. Increased possibilities of choice for importers, the widening of the group of exporting countries, and the increased integration of the European market, thanks to the possibility of redirecting cargoes depending on single countries' supply–demand balance, would contribute decisively to security of supply, market globalization and competition in the industry (IEA, 2004). Consequently, it is possible that some competition between producing countries will also occur (Yanrui, 2002). The focus of the paper will be on the European market. Nevertheless, when necessary, reference to other countries is made according to the global nature of the LNG market.[1] The aim of the paper consists in

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[1] The reference goes here to the lower specificity of the LNG investment that could (at least) partially offset the market segmentation brought about by the pipeline.

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Nomenclature

To simplify the understanding of the paper we summarize here the notation used. In general, variables denoted by capital letters refer to natural gas imported via pipe while variables denoted by lowercase letters refer to LNG. More specifically we have:

Q_R	quantity of natural gas demanded by residential sector
P_R	unit price of natural gas charged to the residential sector
Q_I	quantity of natural gas demanded by industrial sector
P_I	unit price of natural gas charged to industrial sector
P^W	wholesale unit price of natural gas imported via pipe, i.e. price paid by importer to upstream producer
q_R^L	quantity of LNG sold to residential sector
q_I^L	quantity of LNG sold to industrial sector
p_R^L	unit price of LNG for residential sector
p_I^L	unit price of LNG for industrial sector
$q_R^{L_i}$	quantity of LNG sold to residential sector by the *i*th importer (bilateral oligopoly case)
$q_I^{L_i}$	quantity of LNG sold to industrial sector by the *i*th importer (bilateral oligopoly case)
p_W^L	wholesale unit price of LNG
$p_W^{L_i}$	wholesale unit price of LNG for the *i*th LNG importer
p_W^S	wholesale unit price of LNG on the spot market
C^e	natural gas extraction cost
r	regasification unit cost
l	liquefaction unit cost
$\bar{c}$	cost of serving industrial consumers
$\underline{c}$	cost of serving residential consumers

analyzing the effects of an increase in LNG gas imports in terms of competition on the European market. For this reason an oligopoly model developed with reference to different scenarios corresponding to different degree of competition between gas importers. The assumptions and outcomes of the model are discussed in the last section of the article under an empirical point of view on the basis of the current and forecasted structure and developments of the gas sector.

2. The context

The importance of LNG seems to be emphasized by the increased reliance of European consumption on imports. In fact, gas demand forecasts show a considerable increase from the present consumption level to the one foreseen in year 2025[2] (Table 1).

During the same period European import needs will increase because of the depletion of existing gas fields. By the year 2025 Europe will in fact require almost 686 Bcm[3] from external suppliers: that is, 270 Bcm more than 2007.

It is then of paramount importance to look for new supplies coming both from traditional export countries and new exporters. In this context LNG could significantly contribute to European security of supply.

At the moment LNG still has higher costs than those sustained in the pipeline chain.

The table below shows that, for the time being, the average border prices for countries importing via the LNG chain are higher than those for the countries exporting via pipe. The reference goes, in particular, to the average border price for Spain and France (respectively, the first and the second biggest importer of LNG in Europe), that are slightly higher than those of countries that do not resort to LNG (i.e. Germany) or do that just marginally (i.e. Italy).

Higher LNG costs appear evident also by reading the table by columns, which shows that supplies from Algeria (via LNG), Qatar and Egypt are significantly more expensive than those reaching the European via pipe (Table 2).

Nonetheless, the entry of LNG suppliers in the gas market may have a positive impact on the final price because, contrary to what happens with natural gas imported via pipeline, LNG importers' production facilities are not dedicated to a specific upstream producer and this in turn may lead to a more competitive market.

For this reason the LNG trade can be considered as more flexible than import by pipelines. It should be however mentioned that, in theory, flexibility could be achieved also on pipelines provided a liquid secondary market exists. As a matter of fact international transport capacity is owned by national incumbents that tend to withhold it hindering the development of capacity trade. This problem could be partially overcome by the design of an effective regulation regarding capacity allocation mechanisms and congestion management.[4] Nevertheless "technical" flexibility of the LNG chain, represented by the non-specific nature of the investment, and by the possibility to change exporter according to relative conveniences, cannot be reproduced with reference to the pipeline.

That being said it should be argued that a more competitive market structure, together with the fact that LNG production are expected to decrease,[5] could lead to a lower price of gas. Other authors have taken the opposite direction by investigating the effect of a collusive behaviour in the world gas market considering that few countries account for more than 50% of world production of natural gas (see for example Egging et al., 2009; Massol and Tchung-Ming, 2009). Or in a slightly different setting, Polo and Scarpa (2003) have shown that there are cases in which entry in the gas market does not lead to increased competition.

Whether the future market configuration will be more competitive or more collusive is still debated and opinions among scholars and practitioners are divergent. For example Finon and Locatelli (2008) conclude that the chance of having a successful cartel in the natural gas market in the short-term is low and Meritet et al. (2006) consider the entry of GNL in the market for natural gas on both sides of the US–Mexico border as a positive element that is going to increase the competitive conditions of the market. We share their view and we believe that both the competitive forces and the difficulties to sustain a collusive behaviour are strong enough to make a competitive outcome the most likely scenario in the near future.

[2] It has to be considered that gas demand forecasts significantly change according to different sources. In rare cases such as in one of the scenario recently elaborated by the European Commission gas demand is supposed to slightly decline due to the energy efficiency policies and to the development of renewable sources. Anyway gas production in traditional export countries is destined to decline leaving scope for the entrance of new operators on the market.

[3] This figure has been obtained on the basis of domestic production forecasts by Global Insight (2007).

[4] The reference goes here to capacity release programmes, Use It or Loose It clauses, booking mechanisms, etc.

[5] See Section 4.

Table 1
Gas demand forecasts to 2025.
Source: Global Insight (2007). Bcm.

Sectors	2007	2010	2015	2020	2025
Residential	165.2	175.5	189.1	199.6	206.8
Commercial	59.6	63.2	68.4	72.6	76.8
Industrial	156.9	167.5	183.7	197.1	209.1
Generation	176.4	194.8	237.2	280.6	317.5
Total EU 30	**558.1**	**601.0**	**678.4**	**749.9**	**810.2**
Other Balcans	3.3	5.4	6.3	7.3	7.8
Total EU 35	**561.4**	**606.4**	**684.7**	**757.2**	**818.0**

3. The model

In this section we develop a model analyzing the competitive effects of the entry in the gas market of LNG importers. In particular, we would like to analyze whether the construction of LNG terminals and the entry of LNG importers can have a positive effect by reducing gas price and therefore increasing consumers' welfare.

The present model formalizes some plausible scenarios for the gas market in the next years and studies the resulting prices. It analyzes the pricing behaviour in a liberalized market where firms are assumed to be free to choose the price that maximizes their profits with no regulatory constraint. The competitive effect of the entry of LNG importers depends on several factors, including the number of importers and the type of competition that will take place among them and among LNG producers. We consider four possible scenarios. In three of them we restrict our attention to competition among LNG importers and we rule out competition between gas imported via pipeline and LNG by assuming a binding capacity constraint on the pipeline. As a result, the importer of natural gas via pipeline behaves as a monopolist on his segmented market and competition takes place only among LNG importers. The rationale for this assumption is the desire to investigate the characteristics of the LNG market to understand whether it can be competitive with respect to the market for the gas imported via pipe. In the first scenario we assume that LNG market has the same structure of the market for natural gas imported via pipe: one importer with a long-term contract with one producer. The remaining three scenarios, instead, assume that LNG market is an oligopoly with n importers. In the second scenario, we analyze the oligopoly pricing behaviour under the assumption that each importer has a long-term contract with one producer. In the third scenario, instead, we introduce a spot market for LNG so that the quantity needed to meet seasonal fluctuations can be bought on the spot market. Finally, in the last scenario we introduce competition among LNG and natural gas imported via pipe.

We focus our attention on Cournot (quantity) competition.[6] This is because we believe the Cournot model is a more convenient way to capture the characteristics of the natural gas market where capacity is a crucial element (see also Golombek et al., 1998; Holtz et al., 2008).

Furthermore, it has been shown that the Cournot solution is equivalent to the solution of a two-stage game where in the first period firms choose their capacity and in the second period they compete in prices (Kreps and Scheinkman, 1983).

We restrict our attention to only two levels in the natural gas production chain: upstream production and downstream transportation and import. By doing this we look at the competition at import level and we ignore the retail distribution and the problems that may arise at this level (third party access, etc.).

Consider a two-period model where in the first period the whole supply of gas is provided by natural gas imported via pipeline by a monopolist. This of course is a simplification of a more realistic situation with a dominant firm that "makes the market" and with few very small firms that behave as a competitive fringe. However, we believe that this is a reasonable simplification since we are interested in the pricing behaviour of gas suppliers and the competitive fringe has no influence on market price.[7]

In the second period gas demand increases and the constraint given by the capacity of the pipeline becomes binding. As a result the supplier of natural gas via pipe cannot meet the new demand and one or more suppliers of LNG enter(s) the market.

3.1. Demand functions

We simplify matters by assuming there are only two groups of consumers: residential and industrial.

The power sector that is considered as the main responsible for the future increase in demand is here included in the latter for three reasons.

According to the features of consumption gas demand can be substantially divided in two categories, use of gas for heating purposes and use of gas for industrial processes,[8] including power generation. The first use is affected by seasonality while the temperature has no impact on industrial consumption, be it electricity generation or production processes.

Gas demand can be distinguished also on the basis of its elasticity: the residential demand is substantially rigid since natural gas cannot be easily substituted in the heating uses, while demand coming from other sectors is more elastic. Last but not least elasticity of gas demand in the industrial and power sector can be considered as similar. In fact, in both markets, some uses are captive due to the diffusion of "gas oriented technologies" such as combined cycles for electricity generation or the use of gas for technological processes, e.g. the pottery industry, while in others gas can be replaced by alternative fuels: it is the case of power generation in dual-fuel plants or of gas consumption in non-technological industrial productions such as the mechanic industry.

As for seasonality[9] the problem is not considered according to two main relevant issues in the natural gas market: first of all the demand mostly affected by this problem is the demand of the residential sector. In this market the price charged to consumers is usually regulated.[10] This means that in practice the price should

[6] About applications of the standard Cournot and Bertrand paradigms in ex ante analysis of gas and electricity markets see Smeers (1997).

[7] This implies, for example, that we ignore the regulatory constraint imposed by Italian regulator on the amount that the downstream supplier can sell. However, two considerations are in order. First, Italy is one of the few countries with this type of regulation. Second, and more important, firms that purchase gas from the monopolistic importer can hardly be credible competitors of the importer on the retail market.

[8] It should be noted that natural gas consumption by industries also includes gas for heating purposes but this does not conflict with our classification based exactly on heating and non-heating uses.

[9] As for seasonality it could be argued that lumping the industrial and the power sector together is not correct since the former is characterized by a season-invariant demand level while the power sector can be greatly affected by the weather. The reference goes here to the increase in fuel consumption due to the raise in electricity demand for air conditioning uses in the summer. Nevertheless it can be maintained that the industrial and power sectors show a comparable level of variability in consumption if contrasted with the residential demand that proves to be infinitely more dependent on the weather. This represents another reason supporting the distinction of gas demand in just two categories.

[10] The final price regulation for all the segments of the gas chain in Italy was introduced by the national Authority with Resolution 237/00.

Table 2
Average border price of some European countries. Data in $/MMBtu.
Source: Authors' elaboration on WGI data (2007).

To	From							
	CIS	**Nether-lands**	**Norway**	**Algeria LNG**	**Qatar LNG**	**Egypt LNG**	**Algeria pipe**	**Average**
Belgium	–	7.70	7.83	9.82	–	–	–	**8.45**
France	8.44	8.57	8.59	9.72	–	–	–	**8.83**
Germany	8.39	8.55	8.52	–	–	–	–	**8.49**
Italy	8.34	8.57	–	9.75	–	–	6.02	**8.17**
Netherlands	–	–	8.56	–	–	–	–	**8.56**
Spain	–	–	9.32	9.57	12.08	10.68	7.76	**9.88**
UK	–	–	8.42	–	–	–	–	**8.42**
Average	**8.39**	**8.35**	**8.54**	**9.72**	**12.08**	**10.68**	**6.89**	

be rather considered as a tariff and is not affected by demand fluctuations. Moreover natural gas is mostly imported through long-term contract and spot market is very limited at the moment. Leaving aside a detailed description of the price settings mechanism it should be emphasized that the import price is negotiated on the basis of the gas netback value. The latter depends on the price of alternative fuels that change according to the different uses of natural gas. This means that the gas price is affected by the features of demand when the contract is signed but, once it has been set, it changes over time according to the oil quotations dynamic but is not as volatile as the price of crude since renegotiations take place at scheduled times (usually every three years).

So, as a matter of fact, the seasonality issue which is one of the most qualifying features of the gas market does not affect prices directly.

However, in Section 3.6 where we introduce the spot market we allow the demand of the residential sector to fluctuate.

The aggregated demand is the sum of the industrial and residential demands. Let Q_R denote the quantity demanded by residential sector. Then, the inverse demand function for residential sector is given by

$$P_R = a_R - b_R Q_R$$

where $b_R < 1$. In one of the following subsections we will introduce the possibility that demand function of residential consumers is subject to seasonal fluctuations. The idea is to capture the random component in the demand for heating due for example to particularly cold winters.

The inverse demand function for industrial consumers is

$$P_I = a_I - Q_I$$

The two groups of consumers are different also for the commercial cost that the importer bears to serve them. The commercial cost needed to serve residential consumers ($\overline{c}$) is higher than the commercial for industrial consumers ($\underline{c}$) : $\overline{c} > (\underline{c})$.

3.2. *First period: bilateral monopoly in the supply of natural gas imported via pipe*

In the model two time periods are considered according to the target and scheduled implementation of the liberalization process. The latter is meant to drive the transition from a monopolistic to a competitive market. For this reason a first period in which a sole operator acts as monopolist and monopsonist for the importing country[11] and a second period characterized by new entries are considered. As a matter of fact the two time periods are then specified into four scenarios according to the progressive development of the market towards a competitive structure corresponding to the situation illustrated in the last one. In this way none of the relevant cases is neglected.

[11] This situation applies to all European markets.

Let us consider for the moment a market structure with only one downstream supplier which purchases natural gas from an upstream producer. Gas is transported through an existing pipeline. The cost of building the pipeline has already been sunk (and potentially paid back), and therefore we can ignore it. Furthermore, we take as given the capacity of the pipeline. The quantity of natural gas that can be imported via pipe is constrained by the capacity of the existing pipeline and we assume that the quantity of imported gas is such that the pipeline is working at full capacity to meet the first-period demand, both residential and industrial. Let $Q(P^W)$ denote the quantity demanded by the downstream supplier as a function of the wholesale price. Producer's maximization problem is

$$\underset{P^W}{\text{Max}} \quad Q(P^W)(P^W - C^e)$$
$$\text{s.t.} \quad Q \le \overline{Q}$$

where $\overline{Q}$ is the quantity corresponding to full capacity of the pipeline. The producer, who knows the final demand faced by the downstream supplier, anticipates the value of $Q(P^W)$. Then, to solve the model we work backward by solving first the maximization problem of the downstream firm and then finding the optimal price for the upstream producer. Downstream supplier's demand is

$$Q = Q_R + Q_I$$

Downstream supplier and upstream producer have signed a long-term contract with "take-or-pay" obligations so that the downstream supplier has an incentive to exactly cover its obligations.

The cost function of the monopolistic supplier of natural gas via pipe is given by

$$\begin{aligned} C(q) &= P^W(Q_R + Q_I) + \overline{c}Q_R + \underline{c}Q_I \quad \text{if} \quad Q_R + Q_I \le \overline{q} \\ &= w(q - \overline{q}) + P^W(Q_R + Q_I) + \overline{c}Q_R + \underline{c}Q_I \quad \text{if} \quad Q_R + Q_I > \overline{q} \end{aligned}$$

where $\overline{q}$ is the quantity specified in the contract with the producer and $w > P^W$.

However, since we are interested in a situation where the pipeline is already working at full capacity we assume that $\overline{q} = \overline{Q}$ so that the quantity specified in the existing contract between producer and downstream supplier is equal to full capacity. Let us solve the problem of the upstream producer by assuming that the conditions necessary to have positive production are satisfied. We will check later whether they indeed are. Given the wholesale price paid to the upstream producer of gas P^W, downstream supplier optimization problem is given by[12]

$$\max_{P_I,P_R} \quad (a_I - P_I)(P_I - P^W - \underline{c}) + \frac{1}{b_R}(a_R - P_R)(P_R - P^W - \overline{c})$$

We can rewrite the optimization problem with the quantity as choice variable rather than the price to get:

$$\max_{Q_I,Q_R} \quad [(a_I - Q_I) - (P^W + \underline{c})]Q_I + [(a_R - b_R Q_R) - (P^W \overline{c})]Q_R$$

whose solutions are $Q_I = ((a_I - \underline{c} - P^W)/2)$ and $Q_R = ((a_R - P^W - \overline{c})/2b_R)$.

Given the wholesale price paid to the upstream producer of gas P^W and the quantity demanded by the downstream firm as function of P^W, the upstream producer chooses the wholesale price by solving the following maximization problem:

$$\max_{P^W} \quad (Q_I + Q_R)(P^W - C^e) = \left[\frac{(a_I - \underline{c} - P^W)}{2} + \frac{(a_R - \overline{c} - P^W)}{2b_R}\right](P^W - C^e)$$

where C^e is the natural gas extraction cost. The optimal wholesale price is

$$P^W = \frac{(a_I - \underline{c})b_R + (a_R - \overline{c})}{2(b_R + 1)} + \frac{C^e}{2}$$

Finally, given the wholesale price we can find the optimal downstream quantity and price for the industrial sector:

$$Q_I = \frac{(a_I - \underline{c})[2(b_R + 1) - b_R] - (a_R - \overline{c})}{4(b_R + 1)} - \frac{C^e}{4} \tag{1}$$

Let $\gamma = (b_R + 1)$. Then we can rewrite Eq. (1) in the following way:

$$Q_I = \frac{(a_I - \underline{c})[\gamma + 1] - (a_R - \overline{c})}{4\gamma} - \frac{C^e}{4}$$

and the resulting price is

$$P_I = \frac{4\gamma a_I - (a_I - \underline{c})(\gamma + 1) + (a_R - \overline{c})}{4\gamma} + \frac{C^e}{4} \tag{2}$$

In the same way we can determine the quantity and price for the residential sector:

$$Q_R = \frac{(a_R - \overline{c})(\gamma + b_R) - (a_I - \underline{c})b_R}{4b_R\gamma} - \frac{C^e}{4b_R} \tag{3}$$

$$P_R = \frac{4\gamma a_R - (a_R - \overline{c})(\gamma + b_R) + (a_I - \underline{c})b_R}{4\gamma} + \frac{C^e}{4}$$

Eqs. (1) and (3) imply that in order to have positive production for both industrial and residential consumers the following conditions must be satisfied:

$$\frac{(a_R - \overline{c})}{\gamma + 1} + C^e \frac{\gamma}{\gamma + 1} < (a_I - \underline{c}) < (a_R - \overline{c})\frac{(\gamma + b_R)}{b_R} - C^e \frac{\gamma}{b_R}$$

The above price mechanism presents the standard double marginalization problem: the retail price is higher and the quantity sold is lower than, respectively, the price and the quantity we would have with an integrated firm producing, transporting and selling the gas. This is because the producer, when deciding the wholesale price, does not take into account the negative effect that a higher price has on the quantity sold by the importer to consumers.

The downstream supplier profits are given by

$$\Pi = Q_I(P_I - P^W - \underline{c}) + Q_R(P_R - P^W - \overline{c}) = \frac{(a_I - \underline{c} - P^W)^2}{4} + \frac{(a_R - \overline{c} - P^W)^2}{4}$$

3.3. Second period: entry of LNG importers

Gas demand has been constantly growing in the last decades and forecasts for the next decades confirm this trend. Thus, we assume that second period demand is higher so that new facilities, either a new pipeline or new regasification terminals, must be built to meet this growing demand.

It is worth pointing out that this way of proceeding does not mean to consider that capacity can be instantaneously built. In reality since infrastructure takes a long time to be built, investments need to be carefully planned in advance on the basis of forecasted demand and, more in general, market structure.

The assumption made here is that gas demand will increase and that the expected growth is such to justify/incentive new entries on the market allowed by investments started in due time and successively brought on stream to meet consumption. For instance the construction of the Porto Viro regasification terminal in Italy was decided in 2004, much before it came into operation last month, on the basis of an expected growth in demand.[13]

We model this by assuming that second-period demand is equal to first-period demand multiplied by $(1+s)$ where s is a scalar that represents the growth rate of natural gas demand. Then, the new demand function is

$$Q^2 = (1+s)[Q_R^1 + Q_I^1]$$

where superscript indicates the time period. Since in what follows we will analyze only the second period equilibrium so that no confusion should arise on the time period we drop the time index. The simplest case is the one with $s = 1$, i.e. when demand doubles and the following section we will focus on this case.

Given that LNG demand has been rising at an even faster rate than the demand of natural gas, we focus our attention on the entry of one or more LNG importers. Thus, in the second-period the importer of gas via pipeline operates at full capacity but is unable to meet the increased demand.

3.3.1. Rationing

As said before we assume that the pipeline capacity is too small to meet the growing demand for gas. If natural gas importer via pipe operates at full capacity in the first period, the whole increase in second-period demand must be satisfied by LNG importers. We assume that customers are assigned to different suppliers according to a *random rationing mechanism* (called also *proportional rationing*) where all consumers have the same probability of being served by each supplier.[14] The rationing mechanism is important because, as it is shown below, gas is sold at different prices. Of course, all consumers would like to be served by the low price importer. Under proportional rationing or random rationing, the downstream supplier of gas via pipe sells the same quantity as before and the new demand is satisfied by the entrants, i.e. LNG importers. Let the superscript L indicate LNG and lowercase letters indicate the variables that refers to LNG, so

[12] The objective function is strictly concave in prices (the Hessian matrix is negative definite) and this guarantees the uniqueness of the solutions.

[13] And this applies to the majority of the new European regasification terminals.

[14] Alternative hypotheses would be either efficient rationing or cream skimming. See for example Tirole (1988).

that, for example, p_I^L and q_I^L are the price and the quantity of LNG for industrial consumers, respectively.

3.3.2. Regasification capacity choice

After deciding to enter the market, LNG importers decide the capacity of the regasification terminal and finally they decide the quantity of LNG to sell.

Regasification capacity of the terminal will be chosen to minimize the cost of building the terminal given the optimal amount of LNG that the importer wants to sell on the market. Let $R(k)$ be the cost of the regasification terminal as a function of the capacity k. We assume that the cost function $R(k)$ is U-shaped so that there exists a capacity that minimizes the cost of building the regasification terminal. For example if $R(k)=\overline{R}+R(k-8)^2$ we obtain

$$k^{min}=8$$

Then, a capacity of $k=8$ billion m^3 will be chosen provided that the optimal quantity of LNG to be sold on the market is $q^L \le 8$.

The capacity installed is an important element in determining the degree of competitiveness in the market. We need to assume not only that there exists a capacity that minimizes the cost but also that this capacity is larger than the quantity sold by the importer on the market. The choice of the capacity of the regasification terminal, k, sets an upper bound on the quantities the importer can sell: $q_R^{L_i}+q_i^{L_i} \le k$. But if $q_R^{L_i}+q_I^{L_i}=k$ and, in general if importers have a capacity k such that $nk=Q(p^*)$ where p^* is the equilibrium price, then each importer is a monopolist in his market. In order to have a competitive effect, importers must compete on the retail market, and this in turn implies that each importer must have a market share strictly smaller than k: $q_R^{L_i}+q_I^{L_i}<k$. This means that importers must profitably choose a regasification capacity in excess of the one needed. This is profitable only if, given $k^{min}>q_R^{L_i}+q_I^{L_i}$, it follows that[15,16]

$$R(k^{min})<R(q_R^{L_i}+q_I^{L_i})$$

The LNG importer takes the quantity of natural gas imported via pipe as given so that its demand function is the residual demand. If, for example, natural gas demand doubles, the residual demand for LNG is given by $q^L=(a_R-p_R^L)+(a_I-p_I^L)$.

We can now analyze the different competitive scenarios. In the first one, the LNG market structure is given by a bilateral monopoly where the only LNG importer has a long-term contract with a monopolist LNG producer. In the second scenario we analyze an oligopoly with n LNG importers. Also in this second scenario we assume that each LNG importer has a long term contract with an upstream producer, so that there is no competition among producers. In the third scenario we relax the assumption that each importer has a long term contract with a producer for the entire quantity of LNG and we assume that importers have long-term contracts only for a fraction of the quantity sold and the remaining part is bought on the spot market. Thus, in this scenario we study the effect of competition among LNG producers in addition to the competition among importers. Finally, in the last scenario we examine competition between LNG importers and the importer of gas via pipe.

We first assume that the LNG supplier(s) has decided to enter the market and only after solving for the equilibrium quantity and price we check whether the conditions that make entry profitable are satisfied.

3.4. First scenario: bilateral monopoly in the LNG market

Let r be the unit regasification cost of the LNG importer, p_W^L the unit price paid to the LNG producer, and as before $\underline{c}$ and $\overline{c}$ the cost of serving industrial and residential consumers, respectively. The quantity of LNG sold to industrial consumers is the solution of the following maximization problem:

$$\mathrm{Max}(a_I-q_I^L)q_I^L-(p_W^L+\underline{c}+r)q_I^L$$

which is $q_I^L=(a_I-(p_W^L+\underline{c}+r)/2)$. Similarly, the quantity sold to residential consumers is given by $q_R^L=(a_R-(p_W^L+\overline{c}+r)/2b_R)$.

Following the same procedure we used for the gas imported via pipe, we first determine the quantity demanded by the LNG importer as a function of the price paid to the producer. Then, we find the optimal wholesale price. Finally, given the wholesale price we solve for the retail price for LNG. For the moment we assume that there is no difference in the extraction cost for the gas, C^e, regardless of the country where it is produced, so that the entire difference in the cost between gas via pipe and LNG is given by the regasification cost r, and the liquefaction cost l. The first is paid by the importer and the second by the producer. Then, the upstream LNG producer's profit function is

$$\pi=\left[\frac{a_R-(p_W^L+\underline{c}+r)}{2b_R}+\frac{a_I-(p_W^L+\overline{c}+r)}{2}\right](p_W^L-C^e-l)$$

and the optimal wholesale price is[17]

$$p_W^L=\frac{(a_I-\underline{c})b_R+(a_R-\overline{c})}{2(b_R+1)}+\frac{(C^e+l-r)}{2}$$

The wholesale price for LNG is a function of both the regasification cost r and the liquefaction cost l. However, they have opposite sign since they are paid by the two opposite contractual parties.

Given this wholesale price retail quantities are:

$$q_I^L=\frac{(a_I-\underline{c})(\gamma+1)-(a_R-\overline{c})}{4\gamma}-\frac{(C^e+l+r)}{4}$$

and

$$q_R^L=\frac{(a_R-\overline{c})(\gamma+b_R)-(a_I-\underline{c})b_R}{4b_R\gamma}-\frac{(C^e+l+r)}{4b_R}$$

The corresponding prices are:

$$p_I^L=\frac{4\gamma a_I-(a_I-\underline{c})(\gamma+1)-(a_R-\overline{c})}{4\gamma}+\frac{(C^e+l+r)}{4} \tag{4}$$

and

$$p_R^L=\frac{4\gamma a_R-(a_R-\overline{c})(\gamma+b_R)-(a_I-\underline{c})b_R}{4\gamma}+\frac{(C^e+l+r)}{4} \tag{5}$$

By comparing expression (4) with expression (2) it is easy to see that, the retail price for LNG is higher than for gas imported via pipe for both groups of consumers:

$$p_I^L-P_I^*=p_R^L-P_R^*=\frac{(r+l)}{4}>0$$

LNG can be sold at a higher price than gas imported via pipe because of binding capacity constraint on the quantity of gas

[15] Later we will see that excess capacity may be built also to meet random fluctuation of residential demand.

[16] We are implicitly assuming that the technology used to build the regasification plant exhibits increasing return to scale.

[17] It is easy to check that the solution is unique since profit function is strictly concave in p_W.

imported via pipe together with the fact that there is only one LNG importer in this scenario. Thus, the final retail price for natural gas for both groups of consumers will be a weighted average of the two prices.

LNG importers' profits are:

$$\pi^L = (p_I^L - \underline{c})q_I^L + (p_R^L - \overline{c})q_R^L - (P^W - r)(q_I^L + q_R^L) - R(k^{min})$$

3.5. Second scenario: bilateral oligopoly in the LNG market

Suppose now n LNG importers enter the market. Each importer has a long term contract with an upstream producer.[18] The difference with the bilateral monopoly case is that now the LNG importers compete on the final market. The retail market is the only stage at which there is competition because the long-term contracts between downstream suppliers and upstream producers insulate producers from competition.

We make the simplifying assumption that LNG is a homogeneous product and therefore is sold at the same price by the n importers.[19]

As before, we assume that the quantity of gas imported via pipe is given by the capacity of the pipeline so that the whole increase in the demand for gas is met by LNG importers. Then, inverse demand functions for industrial and residential consumers are respectively: $p_I^L = a_I - q_I^L$ and $p_R^L = a_R - b_R q_R^L$. The quantity sold by the ith importer to industrial consumers solves

$$\max_{q_I^{Li}} \quad (a_I - q_I^L)q_I^{L_i} - (p_W^L + \underline{c} + r)q_I^{L_i}$$

where $q_I^L = \sum q_I^{L_i}$. However, since the condition under which LNG importers operate is equal for all of them we anticipate that also the quantity imported will be equal so that $nq_I = \sum q_I$. And similarly for the quantity sold to residential consumers.

Thus, the quantities sold by ith importer as functions of wholesale price are:

$$q_I^{L_i} = \frac{a_I - \underline{c} - r - p_W^L}{(n+1)} \quad \text{and} \quad q_R^{L_i} = \frac{a_R - \overline{c} - r - p_W^L}{b_R(n+1)}$$

Then, each producer solves the following problem:

$$\max_{p_W^L} \quad \left[\frac{a_I - \underline{c} - r - p_W^L}{(n+1)} + \frac{a_R - \overline{c} - r - p_W^L}{b_R(n+1)}\right](p_W^L - l - C^e)$$

and the resulting wholesale price is

$$p_W^{L_i} = \frac{(a_I - \underline{c})b_R + (a_R - \overline{c})}{2\gamma} + \frac{(C^e + l - r)}{2}$$

The quantity demanded by the ith importer to the producer is smaller than the quantity in the bilateral monopoly case. However, the wholesale price charged by the producer is the same as before. This is so because each producer still behaves as a monopolist with the downstream supplier despite the reduction in demand. The larger number of importers does not affect the competitive conditions between each producer and each importer. However, the increase in the number of LNG importers affects the equilibrium quantities and the price in the downstream market where the n importers compete against each other. The quantity sold by importer i to industrial consumers is

$$q_I^{L_i} = \frac{(a_I - \underline{c})(\gamma+1) - (a_R - \overline{c})}{2\gamma(n+1)} - \frac{(C^e + l + r)}{2(n+1)}$$

and the quantity sold to residential consumers is

$$q_I^{Li} = \frac{(a_R - \overline{c})(\gamma + b_R) - (a_I - \underline{c})b_R}{2b_R\gamma(n+1)} - \frac{(C^e + l + r)}{2b_R(n+1)}$$

Aggregate quantity and the resulting market price are given by

$$\begin{aligned}
q_I^L &= \sum q_I^{L_i} = n\left[\frac{(a_I - \underline{c})(\gamma+1) - (a_R - \overline{c})}{2\gamma(n+1)} - \frac{(C^e + l + r)}{2(n+1)}\right] \\
p_I^L(n) &= a_I - q_I^L = a_I - n\left[\frac{(a_I - \underline{c})(\gamma+1) - (a_R - \overline{c})}{2\gamma(n+1)} - \frac{(C^e + l + r)}{2(n+1)}\right] \\
&= \frac{2\gamma(n+1)a_I - n(a_I - \underline{c})(\gamma+1) + n(a_R - \overline{c})}{2\gamma(n+1)} + \frac{n(C^e + l + r)}{2(n+1)} \qquad (6)
\end{aligned}$$

Similarly, the price for residential consumers is given by

$$\begin{aligned}
p_R^L &= a_R - b_R n q_R^{L_i} \\
&= \frac{2\gamma(n+1)a_R - n(a_R - \overline{c})(\gamma + b_R) - n(a_I - \underline{c})b_R + n(C^e + l + r)\gamma}{2\gamma(n+1)} \qquad (7)
\end{aligned}$$

As expected, LNG prices both for industrial consumers (Eq. (6)) and for residential consumers (Eq. (7)) are decreasing in n[20] : an oligopoly structure in the LNG downstream market results in a lower price than a monopoly structure because, even if there is no competition among LNG producers, there is competition among LNG importers. Indeed, the final price derived in Eq. (6) is lower than the price derived in the bilateral monopoly case (see Eq. (4)) for n larger than 1 as can be seen from the following inequalities:

$$p_I^L(n) - p_I^L(1) \le 0 \Leftrightarrow (a_I - \underline{c})(\gamma+1) - (a_R - \overline{c}) - (C^e + l + r)\gamma > 0$$

that is always satisfied because it is the condition that guarantees positive production.

If instead we compare the LNG price with the price of natural gas imported via pipe we can see that LNG oligopoly price is smaller if

$$\begin{aligned}
p_I^L(n) - P_I^* &= \frac{2\gamma(n+1)a_I - n(a_I - \underline{c})(\gamma+1) - n(a_R - \overline{c})}{2\gamma(n+1)} + \frac{n(C^e + l + r)}{2(n+1)} \\
&\quad - \frac{4a_I\gamma - (a_I - \underline{c})(\gamma+1) + (a_R - \overline{c})}{4\gamma} - \frac{C^e}{4} \le 0
\end{aligned}$$

Rearranging and simplifying this expression we find that the price of LNG is smaller than the price of the gas imported via pipe when

$$(a_I - \underline{c})(\gamma+1) + (a_R - \overline{c}) - (C^e + l + r)\gamma - \gamma\frac{(n+1)}{(n-1)}(l+r) \ge 0$$

This condition is more stringent than the one above and we do not know a priori whether it is satisfied. A sufficient (though not necessary) condition for the above inequality to be satisfied is

$$\gamma(l+r) \le 2(a_R - c)[(n-1)/(n+1)]$$

The above inequality means that, under the assumption that the extraction cost is equal for LNG and gas imported via pipe, the liquefaction cost l and regasification cost r must be small relative to the margin in the residential sector. Furthermore, it underlines the importance of the number of LNG importers to determine

[18] We are assuming that there is a sufficient number of LNG producers.

[19] However, the model could be extended to allow for differentiated products.

[20] It can be verified that $sign(\partial p_I^L(n)/\partial n) = sign(a_I - \underline{c})b_R + (a_R - \overline{c})(\gamma + b_R) - (C + l + r)\gamma > 0$ and similarly for the price to residential sector.

when LNG price can become competitive with respect to price of natural gas imported via pipe. Indeed, since the last term on the right hand side is increasing in n, the inequality is more likely to be satisfied for n large. The price for residential consumers is

$$p_R^L(n) = \frac{2\gamma(n+1)a_R - n(a_R-\overline{c})(\gamma+b_R)+n(a_I-\underline{c})b_R}{2\gamma(n+1)} + \frac{n(C^e+l+r)}{2(n+1)}$$

and the comparison between LNG price for residential consumers and the price of gas imported via pipe leads to analogous results to those derived for industrial consumers.

We have assumed that second period demand is $Q^2=(1+s)Q^1$. As long as the gas imported via pipe has a lower price, the pipeline works at full capacity, i.e. $Q^1=Q_R+Q_I$, and the residual demand for LNG importers is $Q^2-Q^1=s(Q^1)$. So far we have derived quantities and prices under the simplifying assumption that $s=1$. It is easy to verify that all qualitative results remain unchanged in a more general formulation with $0<s<1$.

3.5.1. LNG importer's decision to entry

In the previous sections we have assumed that LNG importers enter the market but we have not checked whether entry is profitable. LNG importer i will enter the market if profits, net of the cost of building the regasification terminal $R(k)$, are positive. Let k^{min} be the capacity that minimizes the cost of building regasification terminal. Then, the following condition must be satisfied:

$$\pi^{L_i} \geq 0 \Leftrightarrow (p_R^L - p_W^{L_i} - \overline{c} - r)q_R^{L_i} + (p_I^L - p_W^{L_i} - \underline{c} - r)q_I^{L_i} \geq R(k^{min})$$

To simplify calculations we examine the importers' decision in a simplified setting where we consider only one group of consumers. To facilitate the comparison between LNG and gas via pipe let us consider a simplified model where there is only one group of consumers with demand function given by $P=a-Q$ and commercial cost equal to c. In this simplified setting the price of gas imported via pipe would be $P=(3a+c+C^e/4)$. The wholesale price for LNG is $p_W^L=(a-c-r+l+C^e/2)$ and the price of LNG to final consumers in a oligopolistic market would be

$$p^L = \frac{2a+n(a+c+r+l+C^e)}{2(n+1)}$$

LNG importer profits are

$$\pi^{L_i} = \frac{(a-c-r-l-C^e)^2}{4(n+1)^2} - R(k^{min})$$

and importer enters the market only if $((a-c-r-l-C^e)^2/4(n+1)^2) \geq R(k^{min})$, or $2\sqrt{R(k^{min})} \leq ((a-c-r-l-C^e)/(n+1))$.

By comparing the price of gas imported via pipe and LNG price we have the following inequality:

$$P \geq p^L(n) \Leftrightarrow \frac{3a+c+C^e}{4} \geq \frac{2a+n(a+c+r+l+C^e)}{2(n+1)}$$
$$\Leftrightarrow \frac{(r+l)}{(n-1)} \leq \frac{(a-c-r-l-C^e)}{(n+1)}$$

LNG price is lower than the price of gas imported via pipe only if liquefaction and regasification costs are sufficiently small. If we look at the non-negativity condition on profits it is easy to see that a sufficient (tough not necessary) condition for LNG price being lower than price of gas imported via pipe is $(n-1)2\sqrt{R(k^{min})} \geq (r+l)$ where $R(k^{min})$ is the yearly cost of the regasification terminal. In other words, a sufficient condition is that the unit cost of liquefaction and regasification must be low relative to the yearly cost of building the regasification facility. Observe that since the left term is multiplied by $n-1$ the condition is more likely to be satisfied for n large.

3.6. Third scenario: bilateral oligopoly with an active spot market for LNG

Spot transactions for LNG are becoming more and more important and "short-term trading has been growing more rapidly than the market as a whole" (Brito and Hartley, 2007, p. 1). In this section we check whether our previous findings are robust to the introduction of a spot market. Thus, we change our last scenario to allow each importer to buy part of the gas on the spot market. The demand for natural gas is subject to important seasonal fluctuations: for example a very cold winter increases demand for a few months. Then, it may not be easy to forecast correctly the long-term demand and importers may find themselves in the need of more quantity than expected. We consider a setting where importers have long-term contracts with producers but now we add the possibility to buy LNG also on the spot market to meet unexpected increase in demand.

To simplify matters we maintain also in this section the assumption that there is only one group of consumers, the residential consumers, so that we can drop the superscripts. We further modify the "basic" LNG demand function to take into account temporary fluctuations of the quantity demanded in the following way:

$$Q=(a-P)+\tilde{x}[(\alpha-P)]$$

where $\tilde{x} \in \{0,1\}$ is a binary random variable that takes value 1 when there is an increase in gas demand and 0 otherwise. For example, we could have $\tilde{x}=0$ in the summer and $\tilde{x}=1$ in the winter. Importers' long-term contracts guarantee the "standard" quantity $(a-P)$ while the additional quantity, if any, must be bought on the spot market. This can be due for example, to the fact that it takes time to change the quantity specified in the long-term contract so that LNG importers buy it on the spot market even if the price is higher.[21] In this setting each LNG importer has an additional demand for the spot market equal to

$$q_i^s = \frac{\alpha-r-c-p_w^s}{(n+1)}$$

Then, producers face a total demand on the spot market given by $Q^s=(n(\alpha-r-c-p_w^s)/(n+1))$. From this we can derive the inverse demand: $p_w^s=\alpha-r-c-((n+1)/n)Q^s$.

It is likely that producers have capacity constraint and that production cost is increasing as full capacity is approached. We capture this by assuming that producer i cost function is a step function with marginal cost equal to $\underline{C}^e$ for $q \leq q^{L_i i}$ where q^{L_1} is the quantity of the long-term contract, and marginal cost equal to $\overline{C}^e$ for $q > q^{L_i i}$ with $\overline{C}^e > \underline{C}^e$. Producer i maximizes:

$$\underset{q_i^s}{\text{Max}} \quad q_i^s(p^{ws}-\overline{C}^e-l) = q_i^s\left[\alpha-r-\overline{c}-\frac{(n+1)}{n}(q_1^s+q_2^s+\cdots+q_i^s+\cdots+q_n^s)-\overline{C}^e-l\right]$$

From the first order condition we obtain

$$q_i^s = \frac{n(\alpha-r-c-\overline{C}^e-l)}{(n+1)^2}$$

and from this we derive the spot wholesale price:

$$p_W^S = \frac{\alpha-r-c+n\overline{C}^e+nl}{(n+1)}$$

The wholesale price in a long term contract is still the one derived in the previous section since none of the conditions under

[21] Recall that we have assumed that importers have regasification capacity in excess of the quantity sold, i.e. in excess of the quantity specified in the long-term contract.

which long term contract have been signed has changed. Let $\Delta C^e = \overline{C}^e - \underline{C}^e$ and $\Delta a = a - \alpha$. If we compare the spot price with the wholesale price in a long-term contract we obtain

$$p_W - p_W^S = \frac{(a-r-l-c-\underline{C}^e)}{2} - \frac{(\alpha - r - c + nl + n\overline{C}^e)}{(n+1)} = \frac{(n-1)(\alpha - r - c - \underline{C}^e) + 2(n+1)\Delta a - 2n(l + \Delta C^e)}{2(n+1)}$$

It is easy to see that either price can be lower according to parameter values and, in particular, according to the size of ΔC^e and Δa. If we set $\Delta C^e = 0$ and $\Delta a = 0$, the spot price is always lower than the long-term contract price since $(\alpha - r - \overline{c} - \underline{C}^e) > 0$. We know that ΔC^e can never be negative, while we do not know with certainty the sign of Δa even if we would expect it to be positive though small (a negative Δa would indicate that seasonal fluctuations are larger than "standard" demand). Then, if Δa is small so that seasonal fluctuations are relatively large with respect to "regular" demand and the increase in production cost ΔC^e is large, then the spot price is higher than the price of long-term contract. Note that importers have idle capacity regasification so that they can take advantage of a spot price lower than the price of long-term contract to buy additional quantity. However, the analysis of strategic storage goes beyond the scope of the present model.

3.7. *Fourth scenario: competition between gas imported via pipe and LNG*

In our last scenario we consider a situation where production cost of LNG have decreased to an extent such that LNG has lower cost than natural gas imported via pipe. This could be the result of two different situations. First, a conspicuous reduction in production/liquefaction and transportation/regasification cost of LNG. In alternative we could compare LNG with the cost of natural gas imported via a new pipeline. At the moment LNG is more competitive only for long distances, but this situation could easily change.

Suppose production costs are equal for LNG and gas imported via pipe and let us denote them by C^e. If this is the case and given that LNG market has an oligopolistic structure, LNG price would be smaller than the price of gas imported via pipe. Indeed, if we look at the prices of LNG and of natural gas imported via pipe in the simplified setting with one group of consumers, it is easy to see that if we set $r=0$ and $l=0$ in the expression for LNG price we have that gas imported via pipe is more expensive than LNG:

$$P^* = \frac{3a + c + C^e}{4} > \frac{2a + n(a + c + C^e)}{2(n+1)} = p^L$$

However, since natural gas is a homogeneous product if there are no capacity constraints it must be sold at the same price. If this were not the case LNG importers could profitably increase the quantity specified in the long-term contract "stealing" consumers to the importer via pipe. This in turn would induce the importer via pipe to reduce its price until $P_I^* = p_I^L$. In other words, the importer of gas via pipe and the n LNG importers would compete in the same market facing a second period demand function equal to $Q = (1+s)(a-P)$ where we maintain the assumption $s=1$ so that $Q = 2(a-P)$ and $P = a - (1/2)Q$, where $Q = q_1^L + q_2^L + \cdots + q_n^L + q_{n+1}^P$ and q_{n+1}^P is the quantity of the importer via pipe that we can assimilate to the other LNG importers. In this case the price of gas would be

$$p(n+1) = \frac{(n+1)(a + c + C^e)}{2(n+2)}$$

It is easy to see that this is the lowest price derived in all possible scenarios.

Table 3
Summary of the model's assumptions and outcomes.
Source: Authors' own elaborations.

	Assumptions	***Impact on prices***
Scenario 1	LNG market is a bilateral monopoly	LNG is more expensive than **pipeline** imports
Scenario 2	Entrance of LNG operators with long term contracts and competition	LNG prices are decreasing in the number of importers
Scenario 3	Bilateral oligopoly with development of spot market	Prices varying according to seasonality of demand
Scenario 4	Decreasing costs of LNG and competitiveness to pipelines	Lowest equilibrium price

This result is not surprising given that we have assumed away all liquefaction and regasification costs for LNG and now there is only one market for natural gas with no distinction between gas imported via pipe and LNG. This in turn implies that the number of firms in the market is higher and there is more competition in the downstream market.

4. Empirical analysis

In this paragraph the assumptions contained in the model will be tested with respect to the structure and the perspectives of the developing LNG market. Particular attention will be paid to the price dynamics.

Every scenario will be discussed according to its peculiarity and its outcomes.

To this purpose the assumptions and outcomes of the model are listed in Table 3.

It is worth specifying that the results of the model will not be calibrated to quantitative data since, for the time being, LNG markets are limited in scope, especially with reference to spot transactions, and this technology is still managed by incumbents in most European countries. On the other hand, in markets in which LNG is well developed, such as Japan or other far east markets, it is not possible to contrast LNG to pipeline imports, as it is done in the model, since the former is the only or the predominant way in which gas is supplied to the country.

In particular the following hypothesis will be considered:

- the possibility that operators on the LNG market will increase as it is foreseen in the second scenario;
- the perspectives regarding the development of a spot market as it is considered in the third scenario;
- the future cost break-even between LNG and pipe as it is evaluated in the last scenario.

As for the first scenario it is not necessary to test the assumptions on which the game is based since reality shows that the bilateral monopoly is the structure that best suits the European LNG market. The starting point of the empirical analysis will be represented by gas demand forecasts. The increase in demand is in fact the first condition to ensure the entrance of new competitors on the gas market.

4.1. *Bilateral oligopoly in the LNG market*

In the current LNG market structure[22] (bilateral monopoly) a single gas importer buys gas from a single gas exporter. This

[22] Of course by "market" we refer to the market structure of each single European country.

Table 4
Market structure in import and production of gas.
Source: Benchmarking Report, European Commission (2010).

Countries	Number of companies with more than 5% share of available gas	Share of the 3 biggest companies (%)	HHI
France	2	88	6324
Germany	7	62	1706
Great Britain	More than 20	NA	NA
Italy	3	85	4336
Spain	4	66	1887
The Netherlands	1	88	6841

Table 5
Regasification projects in EU30.
Source: IEFE (2008).

Country	Existent	Under construction	Planned	Speculative	Total
Belgium	1	1	0	0	**2**
Cyprus	0	0	0	1	**1**
France	2	1	0	1	**4**
Greece	1	0	0	0	**1**
Italy	1	1	3	3	**8**
Netherlands	0	0	1	1	**2**
Portugal	1	0	0	0	**1**
Spain	6	0	0	2	**8**
Sweden	0	0	0	1	**1**
UK	1	2	1	2	**6**
Turkey	2	0	0	0	**2**
Total	**15**	**5**	**5**	**10**	**35**

market structure approximates[23] the leading one in almost all European markets.

With the exception of Great Britain the number of companies operating in import and production of natural gas is very limited. The level of concentration seems to be particularly high in the Netherlands and France, followed by Italy, Spain and Germany as it is confirmed by the *Herfindahl–Hirschman* indexes[24] (Table 4).

In this scenario the model tells us that LNG is more expensive than piped gas.

The second scenario considers the same price to importers since producers still operate as monopolists for every single buyer. Nevertheless, price decreases on the retail market provided that several LNG importers enter the market. The higher the number of new importers, the lower will be the final price. This scenario turns into a price for LNG that is lower than the price of piped gas. In particular, the difference between LNG price and piped gas price decreases if the number of LNG operators increase and LNG costs decrease, otherwise the LNG incumbent would earn a rent and retail price would not be shrunk. In other words, the entrance of new importers on the European LNG market is the fundamental condition in order to make LNG competitive (Dorigoni and Portatadino, 2008).

As it is shown in Table 5, the number of new regasification plants is quite high. Speculative projects are projects for which the authorization process is yet to be started and whose construction is far from being sure. Planned plants are those for which the authorization has already been given and that often already hold an import contract for a part of their capacity. Even if we consider only planned and under construction investments, it is possible to argue that the LNG market will be characterized by the presence of new competitors in the future. Moreover, most of the new plants are owned by subjects different from gas incumbents, often pretty new operators on the gas market. Therefore, the assumption made in the model regarding the development of an (at least) oligopolistic market in the LNG sector can be regarded as valid and prices are supposed to decrease in the future. The possible decrease in LNG costs will be discussed afterwards.

4.2. Bilateral oligopoly with an active spot market

Since very often just part of the regasification capacity is covered by a long term take or pay contract and gas demand is subject to considerable seasonal fluctuations it is possible to assume that part of the requested gas is traded on the spot market.

Table 6
LNG trade in the world and in Europe (2004–2006).
Source: Authors' elaboration on BP and IEA data.

Bcm	2004	2005	2006	2007	2008
World					
LNG trade movements	158	189	211	226	257
Total trade movements	679	721	761	776	813
% of LNG on total	*23*	*26*	*28*	*29*	*32*
Europe					
LNG trade movements	33	40	47	53	64
Total trade movements	399	416	418	425	449
% of LNG on total	*8*	*9*	*11*	*12*	*14*

Table 6 shows the growth in LNG trade during the last five years. The share of LNG on global trade movements has increased from 23% to 32%. In Europe the growth has been faster with the weight of LNG trade on total movements moving from 8% to 14%.

In Europe spot transactions have been growing even more rapidly: their weight on total LNG trade has moved from 10% to 25% (Brito and Hartley, 2007).

With reference to demand seasonality short term transactions play a key role in peak-shaving.

The Italian natural gas transport society, Snam Rete Gas, has highlighted that, considering the lowest daily demand, likely to occur in spring or fall, and the highest one, occurring in the winter months (generally January or February), the former is on average half of the latter.

Long term import contracts do grant certain flexibility on both monthly and yearly off-takes but, due to unexpected cold winters or warm summers,[25] the importer could have the necessity to buy further quantities of gas and to apply to the spot market.

The theoretical model suggests that LNG price varies according to the size of seasonal demand fluctuations, resulting in a price higher than the one traded on the long term market, in case of huge imbalances between demand and supply. Nevertheless, the development of a spot market could play a key role in making exporters compete among each other. Anyway, it is worth mentioning that competition on the supply side could occur provided liquefaction capacity exceeds LNG demand. Actually, though, liquefaction capacity is supposed to be quite smaller than

[23] As a matter of fact in many countries, like Italy, the market is characterized by the presence of a dominant operator and other smaller companies that often enter the market through the realization of a regasification terminal. Nevertheless in the first scenario a bilateral monopoly was considered since this structure represented the starting point for almost all Member Sates, though authors are aware that assuming that each country represents a single economic entity may not be correct (Smeers, 2008).

[24] Given that, being 10,000 the maximum value, values greater than 1800 give evidence of concentration on the market.

[25] Gas fired power generation for air conditioning is increasing and is very likely to determine a summer peak, in addition to the winter's one, in gas demand.

Table 7
Utilisation rates of liquefaction capacity to 2020.
Source: IEFE (2008).

Liquefaction plants	2010 (%)	2015 (%)	2020 (%)
Atlantic Basin	77.4	53.6	46.1
Pacific Basin	90.7	57.9	30.1
Middle East	100	98.4	66.9
Total World	**89.5**	**66.8**	**46.3**

Table 8
Utilisation rates of regasification capacity to 2020.
Source: IEFE (2008).

Regasification plants	2010 (%)	2015 (%)	2020 (%)
Europe	71.9	60.1	52.9
America	25.6	12.9	12.5
Asia	49.3	37.6	27.9
Total World	**46.5**	**28.1**	**24.1**

regasification capacity in the future: the latter could double the former (IEFE, 2008).

According to this issue it should be however considered that a share of future liquefaction capacity could be freed by the expected cut in imports for the USA.

The alarming rise in natural gas prices in the last years, in the face of growing US demand and decreasing access to US supplies, led to a concerted drive to build LNG facilities. As a consequence experts predicted North America would be the world's biggest importer of liquefied natural gas by 2010. More recently as a result of significant investments in gas shales by domestic and international companies such as Exxon Mobil, Shell, BP, Eni and Statoil Hydro, the situation has radically changed. Considering current production the US seems to have enough of its own supply to become shortly a net exporter of natural gas. This would make the development of the LNG spot market, whose presupposition is represented by available capacity, more likely than in the past.

Moreover the progressive expiry of existing import contracts could free liquefaction capacity and make an active spot market grow at least in the period necessary to renegotiate or contract a new supply which could be conspicuous according to high transaction costs (Fangfang, 2010). As it is shown in Tables 7 and 8, for instance, in the year 2020 liquefaction capacity will be exploited at an utilisation rate of almost 46% compared to the current 90% rate due to old contracts expiry.

4.3. Competition between LNG and gas imported via pipe

The last scenario in the theoretical model foresees competition between LNG and piped gas. Price is a homogeneous good and for this reason it has to be sold at the same price.

In this paragraph the validity of the assumption that LNG importers can profitably increase their customers' base by stealing consumers to the pipe and that the equilibrium price would be the lowest one is tested.

When assessing the competitiveness of LNG in comparison with pipeline, it must be borne in mind that both represent the sole transport stage of the chain; in fact, also gas extraction costs should be carefully evaluated. With regard to this, extraction costs for Europe's main supplier of natural gas via pipeline, Russia, have significantly increased in recent years while those incurred by some of the producing countries usually exporting through the

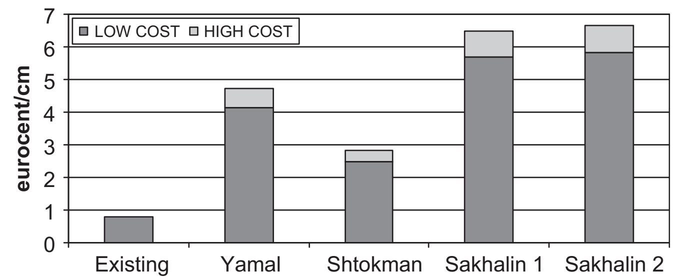

Fig. 1. Production costs from Russian new fields.
Source: IEFE (2008).

Table 9
LNG and piped gas future costs.
Source: IEFE (2008).

Gas chain	Russia	Egypt	Qatar	Libia	Nigeria	Algeria
Extraction	4.2	4.1	2.6	2.6	2.6	2.6
Liquefaction	–	1.7	1.7	1.1	2.1	2.4
Transport	4.0	0.8	1.9	0.6	1.9	0.6
Regasification	–	1.4	1.4	1.4	1.4	1.4
Total	**8.2**	**8.0**	**7.6**	**5.7**	**8.0**	**7.0**

LNG chain are slightly lower (Stern, 2005). The latter issue is of great importance in evaluating the competitiveness of LNG over pipeline. In fact, if considering the sole transport the competitiveness of LNG can be appraised from the distance of 2000–4500 km according to different types of territories. As for the whole chain competitiveness it is necessary to start from a few considerations:

- the main gas exporter via pipe in the world is represented by Russia;
- Russian internal demand is destined to sharply rise in the short and long run;
- demand from old and new importers will increase in the future.

Since production from old fields is being depleted it will be therefore necessary to cultivate new (marginal) fields. Investments aimed at increasing gas production are unfortunately higher than old ones due to technical and geological features. The Russian policy regarding production investments is at the moment not clear insofar as numerous head of agreements with international oil companies are continuously under revision and signed contracts regard just small part of forecasted production (Namikawa, 2003).

All these variables contribute to make the piped gas import price to Europe increase as far as the raw material part of the gas value chain is concerned.

In fact, estimations show that production costs from new fields in Russia could be more than 6 times the current ones (Fig. 1).

Considering the whole chain and comparing LNG costs with pipe costs, it is then arguable that LNG coming from several exporting countries is likely to be cheaper than piped gas, making plausible the assumption adopted in the last scenario of the model (Table 9).

5. Conclusions

The model has analyzed the effect of entry of LNG importers in the market for natural gas under different scenarios. First, we have examined a bilateral monopoly both for the gas imported via pipe and for the LNG that represents the current structure of the gas market, then we have examined the case in which several LNG importers enter the market so that LNG market structure is an (bilateral) oligopoly where each importer has a long term contract with a producer. The long-term contract between producer and importer rules out competition at the producers' level. Then, in our third scenario we relaxed the assumption that the quantity specified in the long-term contract is sufficient to meet the whole demand faced by the importer and we assumed an active spot market for the LNG. Finally, we have assumed that LNG liquefaction cost, transportation and regasification cost can be reduced so that LNG can have lower production cost than gas imported via pipe. For each scenario, we have analyzed the market price for LNG and for the gas imported via pipe.

The main result of the model is that entry of LNG importers in the market for natural gas can have a positive competitive effect even if LNG has higher total cost, but only under some stringent conditions. The main of them can be summarized as follows:

- new competitors must enter the LNG market;
- an active spot market should develop;
- LNG cost should decrease.

The empirical analysis has shown that these conditions are very likely to be fulfilled in the future. In fact, projects relating to new regasification plants are numerous all around Europe, spot transactions are increasing and they could account for a higher share of LNG trade in the next year due to the expiry of the existing contracts and LNG costs will be lower than piped gas costs if considering the whole gas value chain and the expected increase in Russian gas production costs.

In the end, it is possible to conclude that LNG could play a significant role in the liberalization of the European gas market.

Nevertheless clear and effective policies should be developed at the European and national level in order to support market growth and market liquidity. As for the first target incentive to investments by new competitors should be provided. To this purpose the capacity exemption principle has been confirmed by the last gas Directive (73/09) and in numerous European countries an enhanced rate of return on invested capital is foreseen for new infrastructures, including LNG terminals.

This provision should be more incisively applied to LNG considering its potential contribution to competition both on the downstream and on the upstream market, insofar as this technology could introduce a certain degree of competition also among exporters, though limited to spot traded quantities and to certain periods of the year according to the demand dynamics.

Market liquidity should be enhanced by creating a regulatory environment favourable to spot transactions with reference to access to the system. This involves capacity allocation mechanisms, congestion management procedures, booking rules and access to other flexibility instruments that could alleviate the quantity and price risk operators have to face on a competitive market.[26]

Under this point of view the development of the LNG market can be seen as a part of a more complex strategy that should follow an all-embracing approach.

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[26] The reference goes here to price volatility and possible supply constraints that characterize spot markets.