Energy Economics 78 (2019) 174–181

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

LNG import quotas in Lithuania – Economic effects of breaking Gazprom's natural gas monopoly☆

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ARTICLE INFO

Article history:
Received 23 October 2017
Received in revised form 19 October 2018
Accepted 22 October 2018
Available online 12 November 2018

JEL classification:
L13
L95

Keywords:
Natural gas market
Liquefied natural gas
Volume quota
Market power

ABSTRACT

Until 2014, Russia's Gazprom had a natural gas monopoly in Lithuania. In order to break the Russian monopoly, the Lithuanian state financed an import terminal for liquefied natural gas (LNG) in Klaipėda. In addition to building the terminal, Lithuania signed a long-term contract (LTC) which can be interpreted as a minimum import volume quota for LNG having higher marginal supply costs than Russian gas. This study assesses the potential of such a minimum import volume quota to mitigate the market power of a monopolistic supplier. A market consisting of a dominant supplier with low marginal supply costs and a competitive fringe with high marginal supply costs is analyzed. It is shown that there is a minimum import volume quota for fringe supplies that optimizes the consumer surplus, which is adjusted by a compensation paid for the fringe's market entry. Therefore, the Lithuanian decision to incentivize the market entry of high-cost LNG can be rationalized.

1. Introduction

In recent years, natural gas prices in Eastern Europe have been significantly higher than in Central or Western Europe (ACER, 2016), primarily due to the dominant position of Russia's gas exporter Gazprom in the Eastern European gas markets (Henderson and Mitrova, 2015). As of 2013, several European Union (EU) member states were subject to a Russian gas supply monopoly: Lithuania, Latvia, Estonia and Finland (ACER, 2014). Apart from the economic disadvantages resulting from Gazprom's monopoly, political actors in those countries feared that Russian gas deliveries could be used as a political tool by the Russian administration. Against this background, Lithuania, built an import terminal for liquefied natural gas (LNG) in Klaipėda in 2014 with financial support from the EU to allow LNG suppliers access to their market, thus breaking Gazprom's monopoly (Pakalkaité, 2016).

Although the political goal of supply diversification was achieved by this measure, an economic assessment of the terminal crucially depends on global LNG market developments.[1] Lithuania secured a long-term contract (LTC) with the Norwegian supplier Statoil in 2014 to provide must-run LNG imports ensuring the continuous utilization of the newly built terminal. The marginal supply costs of Gazprom were generally considered to be much lower than those of LNG, which has to be liquefied, transported by ship and regasified at the destination. In addition, there was a global scarcity of liquefaction plants in the mid-2010s, which led to a high utilization of existing plants and an increase in LNG prices compared to previous years (International Gas Union, 2015).

The objective of this paper, therefore, is to investigate the economic rationale behind the Lithuanian policy to incentivize must-run imports of high-cost LNG. Such incentives may not be necessary in the case of comparably low LNG prices, i.e. LNG would be imported without a minimum import requirement if an LNG import terminal has been constructed. However, the LTC leads to economic disadvantages for the owner of the LNG terminal if LNG import prices

☆ Acknowledgments: We thank Marc Oliver Bettzüge and Felix Höffler for valuable input. Furthermore, we thank Joachim Bertsch, Harald Hecking, Helena Meier, Martin Paschmann and Johannes Wagner for useful feedback. The paper benefited from the ENERDAY conference in Dresden in 2016, the 1st IAEE Eurasian Conference in Baku in 2016 and from the ewi/FCN research workshop in 2017. Additionally, we are thankful to two anonymous referees.

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[1] LNG is a global commodity as analyzed by e.g. Barnes and Bosworth (2015).

https://doi.org/10.1016/j.eneco.2018.10.030
0140-9883/

are higher than the gas price paid to the dominant supplier. If the owner of the LNG terminal is the state, as is the case in Lithuania, the potential losses generated by the LNG imports are then passed on to the citizens or gas customers in one way or another. Hence, one would intuitively think that securing a LTC for LNG may induce additional burdens for gas customers in situations with comparably high LNG import prices. However, the study at hand argues that a minimum import requirement for LNG could enhance Lithuanian national welfare[2] even if the LNG import prices would be above the former Russian monopoly price. This is due to the reaction of the dominant supplier on the market intervention. Hence, the Lithuanian decision to build the terminal and sign a LTC can be rationalized as a feasible instrument to address Gazprom's market power.

Generally speaking, our analysis investigates a market consisting of a dominant supplier with low marginal supply costs and a competitive fringe with high marginal supply costs. In this setting, a minimum volume quota[3] for the fringe supply is considered. It is shown that a minimum volume quota can increase the consumer surplus of an importing country adjusted by the compensation payments necessary to introduce the quota.

The structure of the paper is as follows: Section 2 gives an overview of the literature relevant for this analysis. Section 3 focuses on a stylized model in which the implications of a minimum volume quota are discussed analytically. In Section 4, the model is applied with parameters characterizing the Lithuanian gas market in 2014. Finally, Section 5 concludes.

2. Literature review

There are two aspects of our research that, to the best of our knowledge, have yet to be investigated in the literature. First, a minimum import volume quota for a high-cost fringe as a trade policy instrument to increase the consumer surplus of a national market is a novelty. Second, the application of this policy instrument to the Lithuanian natural gas market is new. We have identified three different branches of literature that are relevant for our investigation: 1) literature on (strategic) trade theory, 2) industrial organization literature focusing on fringe-firm intervention and multiple sourcing, and 3) literature on the Lithuanian natural gas market.

Strategic trade theory (also referred to as "strategic trade policy") investigates policy instruments affecting the output of a dominant foreign firm. Within the literature, there exist several studies analyzing the effects of tariffs and quotas for the national welfare of a country. The first seminal work to examine the equivalence of different trade restrictions was Bhagwati (1965). He shows equivalence of tariffs and quotas for a market configuration with a dominant foreign firm and a domestic producer that is assumed to be competitive. Based on his findings, but relaxing the assumption of a competitive domestic producer, Shibata (1968), Yadav (1968) and Bhagwati (1968) show non-equivalence of tariffs and quotas because the domestic producer benefits from monopoly power under a quota. Furthermore, Hwang and Mai (1988) illustrate that the equivalence of tariffs and quotas also depends on the market behavior of the firms analyzed. By using a conjectural variation approach with different conjectures, they expose that equivalence holds only for the Cournot case. Other works investigate quotas and tariffs separately. Brander and Spencer (1981), for instance, analyze tariff policies in an imperfectly competitive market. They show how a tariff can be used to extract rents from a foreign exporter. Moreover, their results illustrate the benefits regarding the national welfare of using a tariff to support the market entry of a domestic firm. Eaton and Grossman (1986) focus on Bertrand competition rather than Cournot competition analyzing the welfare effects of trade policy under oligopoly. They find that a tax optimizes national welfare with Bertrand competition. Breton and Zaccour (2001) focus on import quotas in an abstraction of European gas markets in the 1980s. They consider an asymmetric oligopoly with a diversification constraint on a player representing the Soviet Union. Krishna (1989) studies the effect of an import quota in a duopoly of a home firm and a foreign firm. He examines the increasing profitability of a home firm that is able to raise its prices when imports are restricted. He shows that the home consumers are the losers of the maximum import quota.

The aforementioned literature analyzes instruments having a direct effect on the dominant supplier. A minimum quota in our study supports the market entry of the high-cost supplier and has thereby only an indirect effect on the output of the dominant firm. A similar effect is examined by Brander and Spencer (1985): Based on a two stage game, they show that export subsidies may be an attractive trade policy instrument from a domestic point of view. While governments set subsidies in a first stage, firms set their output levels based on the subsidy and on the rivals' output in a second stage. The results of Brander and Spencer (1985) illustrate that the export subsidy lowers a good's world price and increases the domestic firm's profit by extracting rents from the foreign firm. Whereas the subsidy analyzed in the work of Brander and Spencer (1985) supports the domestic producer, the study at hand considers a minimum import quota to incentivize the entry of an external high-cost competitive supplier. A recent application of strategic trade theory to gas markets in a cooperative game theory framework is Ikonnikova and Zwart (2014). Similar to our analysis, they focus on a setting in which both buyers and sellers have market power. They find that trade restrictions like quotas can increase buyers' countervailing market power. However, their focus is on strategic externalities among several buyers, whereas our study concentrates on a single pair of buyer and dominant seller in a non-cooperative game theory framework.

A further stream of literature that is relevant for this analysis can be clustered under the concepts of multiple sourcing and fringe-firm intervention as part of the literature on partial industry regulation. According to Ayres and Braithwaite (1992), fringe-firm intervention means that a regulator or private company supports the entry of a competitive fringe into a market with a dominant player. In line with Stigler (1964) and Tirole (1988), an increasing number of competitors in a market results in increasing competition. Hence, competition is induced without a direct regulatory restrain to the dominant firm. Examples for markets in which fringe-firm intervention takes place are the defense or the automotive industry, e.g. Riordan and Sappington (1989), Farrell and Gallini (1988), Anton and Yao (1987) and Demski et al. (1987). However, literature on fringe-firm interventions of private companies is limited because private companies are faced with a free-rider problem: If one company decides to support the market entry of a competitive fringe, and the fringe produces an input for the company, also the company's competitors would benefit. Moreover, the examples provided in the literature focus on complex and differentiated goods as defense systems. In our work we analyze the market for natural gas, which is a homogeneous good. An import quota as investigated in the following, is only applicable to a homogeneous good.

There are only a few contributions in the literature on resource markets addressing the Lithuanian energy market. Works that include the Baltic gas markets in analyzing the European gas security of supply are e.g. Richter and Holz (2015) and Baltensperger et al. (2017). Hinchey (2018) discusses Russian natural gas pricing in Europe in the presence of alternative supply options for gas. In doing so, a special focus is put on the Lithuanian LNG terminal. Similar to our paper, Hinchey (2018) finds that importing LNG

[2] Due to the fact that Lithuania does not have indigenous natural gas resources and thus no production, national welfare is identical to the consumer surplus.

[3] A volume quota means that a fixed amount of fringe volume needs to be imported in the market. A share quota, however, would mean that a certain share of the demand needs to be supplied by the fringe.

was economically rational for Lithuania. However, her focus is rather on a bargaining solution than on a non-cooperative game. In addition, compared to the analysis of Hinchey (2018) who only examines prices, our study evaluates the welfare impacts of LNG imports for the Lithuanian gas market.

3. Theoretical model

Before the Lithuanian natural gas market is analyzed in more detail, the effect of a minimum import quota on a market for a homogenous good is analyzed within a theoretical framework. First, general functional forms of the cost and supply functions in the model are considered. Later on, linear simplifications for those functions are used.

3.1. General model setup

A country demands a homogeneous good q from abroad. The demand is given by $q(p)$, and $p(q)$ is the inverse demand function. The law of demand is assumed to hold.

There are two sources for the good: (i) a dominant supplier D and (ii) a competitive fringe F. The cost functions of both supply sources $C_D(q)$ and $C_F(q)$ are convex. The dominant supplier is more cost efficient than the competitive fringe, i.e. has lower marginal supply costs: $C_D'(q) < C_F'(q)$. The importing country considers introducing a quota L for imports from the competitive fringe. The question is whether a quota increases national welfare, and how it is optimally chosen. We analyze this in a two stage interaction model. In the first stage, L is determined by the country with the objective to maximize national welfare, which is equivalent to the consumer surplus in the absence of indigenous production. Afterwards, there is supply by the dominant supplier and the fringe firms.[4]

Fringe firms sell their output at the marginal cost $C_F' = \frac{\partial C_F(L)}{\partial L}$ to meet the quota, i.e. their output equals exactly the quota L. Thus, the country's expenditures for the import from the fringe firms will be $L \cdot C_F'(L)$. The dominant supplier takes the quota as given and maximizes profit with respect to the residual demand $q_R(p) = q(p) - L$. Graphically, the residual demand is a parallel shift of the demand function. The dominant supplier chooses a quantity q_D^*:

$$q_D^* \in \arg\max_{q_D} p\left(q_D + L\right) \cdot q_D - C_D\left(q_D\right). \tag{1}$$

The optimal q_D^* is a function of L. The country chooses L^* to maximize national consumer surplus adjusted by a compensation paid to the fringe firms (from now on called "adjusted consumer surplus"):

$$L^* \in \arg\max_{L} CS(L), \tag{2}$$

$$\text{where} \quad CS(L) = \int_0^{q_D^*+L} p(x)dx - p\left(q_D^*\right) q_D^* - LC_F'(L). \tag{3}$$

Assuming an interior solution, the optimal national quota is given with $C_F'' = \frac{\partial^2 C_F(L)}{\partial L^2}$ by

$$\frac{\partial CS}{\partial L} = \left(1 + \frac{\partial q_D^*}{\partial L}\right) p\left(q_D^* + L\right) - \frac{\partial q_D^*}{\partial L}\left(\frac{\partial p}{\partial q_D}\bigg|_{q_D = q_D^*} \cdot q_D^* + p\left(q_D^*\right)\right) - C_F'' L - C_F' = 0. \tag{4}$$

[4] Similar to the game in the seminal analysis of Brander and Spencer (1985), the country's action takes place before the firm's actions. Brander and Spencer (1985) mention that the market intervention announced by the government is assumed to be credible as the reason why the country is able to move first.

This can be reformulated as follows:

$$p(q_D^* + L) - C_F' - C_F'' L = -\frac{\partial q_D^*}{\partial L} p\left(q_D^* + L\right) + \frac{\partial q_D^*}{\partial L}\left(p\left(q_D^*\right) + \frac{\partial p}{\partial q_D}\bigg|_{q_D = q_D^*} \cdot q_D^*\right). \tag{5}$$

On the left hand side of Eq. (5), there is the change in consumer surplus due to receiving one (marginal) unit more from the fringe firms when (marginally) increasing the quota: The first term represents the additional consumer surplus, the second term the cost for the additional unit, and the third term the change in cost for all inframarginal units bought from the fringe. On the right hand side, there is the change from the reaction of the dominant supplier. If the supply of the dominant supplier decreases ($\partial q_D^* / \partial L < 0$), the consumer surplus is reduced (first term). However, less supply from the incumbent saves the cost for this reduced supply (first part of the expression in brackets in the second term) but also drives up the price for all inframarginal units (second part of the expression in brackets in the second term).

A strictly positive quota $L > 0$ is optimal, if the following condition holds:

$$\frac{\partial CS}{\partial L}\bigg|_{L=0} = \left(1 + \frac{\partial q_D^*}{\partial L}\right) p\left(q_D^*\right) - C_F'(0) - \frac{\partial q_D^*}{\partial L}\left(\frac{\partial p}{\partial q_D}\bigg|_{q_D = q_D^*} \cdot q_D^* + p\left(q_D^*\right)\right) > 0. \tag{6}$$

Proposition 1. *A strictly positive quota, $L > 0$, increases the importing country's adjusted consumer surplus if (a) the fringe firms' marginal costs are not too high, i.e. $C_F'(0) < \left(1 + \frac{\partial q_D^*}{\partial L}\right) p\left(q_D^*\right) - \frac{\partial q_D^*}{\partial L}\left(\frac{\partial p}{\partial q_D}\Big|_{q_D = q_D^*} \cdot q_D^* + p\left(q_D^*\right)\right)$, and (b) the inverse demand function is not too convex, i.e. $\frac{C'' - p'}{q_D^*} > p''$.*

Proof. The first order conditions of the dominant supplier's problem are given by

$$\frac{\partial p}{\partial q_D} q_D + p\left(q_D + L\right) - \frac{\partial C_D}{\partial q_D} = 0. \tag{7}$$

Thus, for an interior solution q_D^* satisfying this condition, the implicit function theorem implies

$$\frac{\partial q_D}{\partial L}\bigg|_{q_D = q_D^*} = \frac{-p'}{p'' q_D^* + 2p' - C_D''}. \tag{8}$$

The numerator of the right hand side of Eq. (8) is positive because p' is negative due to the law of demand. The denominator, however, is negative because of the second order conditions of the dominant supplier's problem. Hence, the total expression on the right hand side of Eq. (8) is negative. The right hand of Eq. (8) is larger than -1 if and only if $C'' - p' > p'' q_D^*$, which holds as long as p'' is not too large, i.e. if the inverse demand function is not too convex. In that case, $0 > \frac{\partial q_D^*}{\partial L} > -1$ holds. This means that the first and the third term of Eq. (6) are strictly positive (note that the dominant supplier's optimization implies that the expression in brackets in the third term is weakly larger than the (positive) dominant supplier's marginal costs). In that case, the left hand side of Eq. (6) is positive if $C_F'(0)$ is not too large. □

The requirement that the fringe's marginal costs should not be too high intuitively makes sense. Importing fringe volume by the quota is

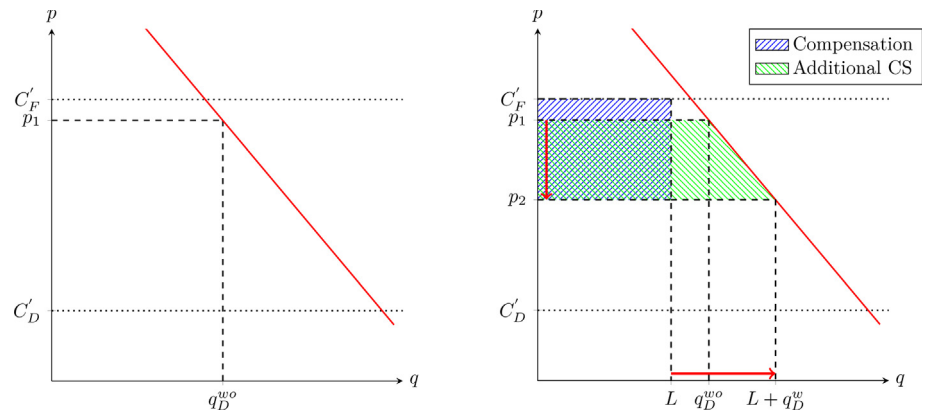

Fig. 1. Market without a quota (left hand side) and with a quota (right hand side).

more expensive, the higher the marginal costs of the fringe. The condition about the convexity of the inverse demand function, however, is more difficult to interpret intuitively because there are two opposing effects: 1) A very convex inverse demand function implies that a parallel leftward shift of the inverse demand will ceteris paribus lead to higher outputs by the dominant supplier (for any q_D, the slope of the inverse demand is flatter, and placing additional units in the market requires a smaller decrease of price). This leads to a decrease in price. 2) However, the additional consumer surplus due to the decrease in price is small if the inverse demand is very convex. Then, a situation can occur in which the compensation paid to the fringe exceeds the additional consumer surplus leading to a negative total effect.

Besides the impact of the quota on the importing country's adjusted consumer surplus, the total welfare (including the producer surplus of the dominant supplier and the fringe firms) is of interest. The welfare is defined as

$$W(L) = \int_0^{q_D^*+L} p(x)dx - C_D\left(q_D^*\right) - C_F(L). \tag{9}$$

As shown in Appendix A, the welfare does not increase if a positive volume quota is introduced.

3.2. Optimal quota for linear inverse demand and cost functions

As a simplification, we now assume a linear inverse demand function:

$$P(q_D + L) = \alpha - \beta \cdot (q_D + L). \tag{10}$$

Additionally, linear cost functions for the dominant supplier D and the fringe F are assumed:

$$C_i(q_i) = a_i + C'_i \cdot q_i \text{ for } i = D, F. \tag{11}$$

Plugging this into Eq. (5), we get the following expression:

$$L^* = -\frac{1}{\beta} \cdot C'_F + \frac{\alpha}{\beta} + q_D^* \cdot \frac{\partial q_D^*}{\partial L}. \tag{12}$$

Eq. (8) becomes for the linear simplification: $\frac{\partial q_D^*}{\partial L} = -\frac{1}{2}$. Then, the following solution is obtained:

$$L^* = -\frac{1}{\beta} \cdot C'_F + \frac{\alpha}{\beta} - q_D^* \cdot \frac{1}{2}. \tag{13}$$

$$q_D^* = \frac{C'_F - C'_D}{\frac{3}{2}\beta}. \tag{14}$$

Fig. 1 illustrates the effect of the minimum import quota schematically for linear inverse demand and cost functions. On the left hand side, the situation without a quota is shown. No fringe volumes enter the market due to the fringe's high constant marginal supply costs. On the right hand side, the quota has been introduced. It can be seen that the volumes supplied by the dominant supplier are reduced by the introduction of the quota. However, because the dominant supplier has market power, the reduction of her volume, $\frac{L}{2}$, is lower than the quota volume, L. Hence, the total supplied volumes increase by the introduction of the quota leading to a decrease in price and to additional consumer surplus. However, since the marginal supply costs of the fringe exceed the resulting market price, the fringe firms must be compensated for the difference between the market price and marginal supply costs. Although the additional consumer surplus is reduced by this compensation, there is still a positive effect on the consumer surplus.

After it was shown in general that it is possible to design volume quotas optimizing the consumer surplus adjusted by payments to the fringe firms, the introduced model is applied to the case of the Lithuanian gas market in the next section.

4. Application to the Lithuanian natural gas market

As outlined in the introduction, the Lithuanian gas market changed in 2014 from a monopoly structure to a market structure with a dominant supplier having low marginal supply costs and a competitive fringe having high marginal supply costs. In addition, Lithuania signed a LTC for LNG, which can be interpreted as a minimum volume quota for LNG allowing us to apply the theoretical considerations developed in Section 3 to the Lithuanian gas market.

4.1. Background

In absence of natural gas resources, Lithuania is 100% dependent on imports. Because the country was a former part of the Soviet Union, its only import pipeline is connected to Russia. Prior to December 2014, when the LNG import terminal in Klaipėda started operation, Gazprom had a monopoly for gas sales to Lithuania, which resulted in comparably high gas prices (ACER, 2015). In the fourth quarter of 2014, the Lithuanian gas price was 408 €/1000 m^3, whereas the gas price at the Dutch hub Title Transfer Facility (TTF), the most liquid European gas hub, was 247 €/1000 m^3 (European Commission, 2014).

In addition to building the LNG terminal, Lithuania signed a LTC with Norway's Statoil with an annual contracted quantity (ACQ) of 0.55 bcm and a take-or-pay (TOP) volume of 0.44 bcm of LNG.[5] The LNG price was based on the natural gas price of the National Balancing Point (NBP), the natural gas hub of the United Kingdom, with a surcharge (Pakalkaité, 2016).

Historically, the purpose of LTCs in the gas industry was to mitigate price and volume risks and ensure the usage of certain infrastructure elements, e.g. pipelines and LNG terminals. In the Lithuanian case, this may have been a motivation behind signing the LTC, too. However, it is clear that the LTC would be a bad decision from the point of view of a profit optimizing terminal owner if the marginal supply costs of LNG would be above the gas price in the Lithuanian gas market (the price having to be paid to Gazprom). Because the marginal supply costs of LNG are higher than the marginal supply costs of Russian gas, there is indeed the risk of such unfavorable market conditions for the LNG terminal. Therefore, it is unlikely that private actors would have financed a LNG terminal in Lithuania. Indeed, no actor other than the Lithuanian state took the risk of the investment. The costs of the investments were passed on to the gas customers by supplements on gas (Pakalkaité, 2016). However, even in the absence of a private business case for the terminal, the enhancing effects of minimum import quotas for the consumer surplus discussed in Section 3 indicate that the decision of the Lithuanian state to build the terminal and sign a LTC can be rationalized from a domestic point of view.

The assumptions of the model framework described in Section 3 fit well for the Lithuanian gas market. Due to the coupling of the LTC prices to the NBP, the LNG imports can be assumed to be competitively priced, even though the LTC was secured with only one company. As in the theoretical model, capacity constraints of the gas infrastructure are not relevant for Lithuania. The pipeline connection from Russia allows imports of more than 10 bcm/a and the LNG terminal has a regasification capacity of 4 bcm/a (Gas Infrastructure Europe, 2017), whereas the Lithuanian gas demand was only 2.54 bcm in 2014 (IEA, 2016).[6]

4.2. Initial monopoly situation

In this subsection the monopoly situation before the construction of the LNG terminal is considered. The analysis is based on linear functions for the inverse demand and supply costs.[7]

In line with Bros (2012), marginal costs for Russian gas of 0.07 €/m^3 are assumed.[8] We introduce a reference price P_{ref}, a reference demand D_{ref} and a point measure for the price elasticity of demand ϵ. The parameters of the inverse demand function α and β can be related to those parameters:

$$\beta = -P_{ref}/D_{ref}/\epsilon, \tag{15}$$

$$\alpha = P_{ref} + \beta \cdot D_{ref}. \tag{16}$$

Due to the fact that the Lithuanian LNG terminal was commissioned in December of 2014, it is assumed that the average price and demand situation in 2014 still corresponded to a monopoly situation. With the historic demand of 2.54 bcm and the price of 394 €/1000 m^3 that is the weighted average price of Russian gas deliveries to Lithuania in 2014 (European Commission, 2016) the point elasticity is chosen so that the monopoly quantity matches the reference demand. Then, the monopoly price also corresponds to the reference price by construction. This value of the point elasticity is given by

$$\epsilon = \frac{P_{ref}}{C_D' - P_{ref}}. \tag{17}$$

With the parameters discussed above, this results in a point elasticity of −1.22.[9] As can be seen in Table 1, this parameterization leads to a Russian profit Φ of 822 million Euro while the Lithuanian consumer surplus CS is 411 million Euro. After discussing the monopoly situation, the impact of LNG imports on the Lithuanian market will be analyzed in the next section.

4.3. The effects of a minimum LNG import quota

Based on the inverse demand function of 2014, the Lithuanian decision to sign the LTC for 0.44 bcm/a of LNG is now evaluated. Because the marginal supply costs C_F' of LNG were uncertain when the LTC was signed, market implications of LNG imports are discussed in dependence on the costs C_F'.

The left hand side of Fig. 2 illustrates the Lithuanian LNG import volumes when the costs C_F' are varied. The figure shows three different setups: (1) imports without a quota (solid graph), (2) imports with the quota of 0.44 bcm/a as introduced by the Lithuanian government (dashed graph), and (3) imports with an optimal quota maximizing the adjusted consumer surplus as described in Section 3 (dashed-dotted graph). Without a quota, LNG enters the market at costs C_F' lower than the monopoly price of 394 €/1000 m^3, whereas no LNG imports would take place if the costs C_F' would be above the monopoly price. However, with the Lithuanian quota, at least 0.44 bcm of LNG would be imported irrespective of the costs C_F'. With the optimal quota, more LNG compared to the two other illustrated cases would be imported. For instance, the optimal minimum import quota would be approximately 1.7 bcm at the monopoly price.

The right hand side of Fig. 2 shows the development of Russian gas imports in dependence on the marginal supply costs for LNG for the case without a quota, with the Lithuanian quota and an optimal quota. Obviously, a binding import quota for LNG lowers the gas imports from Russia compared to the case without a quota.

After discussing the implications of a minimum quota on import volumes, the effects on gas prices are analyzed in a next step. Hereto, Fig. 3 shows the Lithuanian gas price in dependence on the LNG costs C_F'. As long as the import requirement is over-fulfilled, the prices without a quota and with the Lithuanian quota (solid and dashed graphs) are matching and correspond to the costs C_F'. In other words, the marginal supply costs of LNG set the price in the Lithuanian gas market. However, at high costs C_F', the Lithuanian gas price

[5] It is assumed that the TOP volume is 80% of the ACQ. This is a typical annual flexibility for LTCs (Franza, 2014).

[6] Even if the interconnection point between Lithuania and Latvia in Kiemėnai having a capacity of 2 bcm/a would be fully used to reexport gas from Lithuania, Russian import pipeline capacities would still be sufficient to cover the Lithuanian demand and the reexports to Latvia.

[7] In order to quantify the effects of a minimum import quota, certain functional forms for the demand and supply curves have to be considered. Linear functions are a straightforward approach, since any function can be approximated by a linear function in a small range around a certain point. However, as shown in the previous section, more sophisticated functional forms would not change the key result there is a rationale behind incentivizing the LNG imports to Lithuania as long as the demand function would not be too concave and the marginal costs of the LNG suppliers would not be too high.

[8] This includes the Russian gas production costs, mineral extraction tax and transportation costs in Russia. However, the Russian export duty is not included as a cost component because it is considered to be part of the Russian producer surplus from exporting gas.

[9] This is close to −1.25, which is the empirically determined value for the long-run price elasticity of natural gas demand according to Burke and Yang (2016). As also mentioned by Burke and Yang (2016), the literature reports small (inelastic) values for the price elasticity in the short-run. Especially for households, the demand is usually assumed to be very inelastic in the short-run due to the requirement to heat in the cold period of the year. Since a monopolist chooses a point on the elastic segment of the demand function according to basic economic theory, it seems plausible that his pricing behavior is rather determined by the long-run price elasticity of demand.

Table 1
Characteristics of the Lithuanian gas market in 2014.

Parameter	Value	Unit
C'_D	70	€/1000 m^3
P_{ref}	394	€/1000 m^3
D_{ref}	2.54	bcm
ϵ	−1.22	–
CS	411	Million €
Φ	822	Million €

with the quota of 0.44 bcm/a is lower than the gas price without a quota. In such situations, private owners of the LNG import terminal would generate a loss because their expense per imported LNG unit, C'_F, would be above the price in the market. In 2014, the average global LNG price was approximately 445 €/1000 m^3 (International Gas Union, 2015). Hence, LNG prices above the Lithuanian monopoly price were historically already observed. With an optimal import quota, the Lithuanian gas price is below the price without a quota as long as the marginal LNG costs C'_F are above the dominant supplier's marginal costs C'_D.

Besides gas prices, the influence of the LNG import quota on the Lithuanian consumer surplus adjusted by the payment for the LNG imports is analyzed. Fig. 4 illustrates the adjusted consumer surplus in dependence on the marginal supply costs C'_F. In line with the conventions in the previously discussed diagrams, the function illustrated by the dashed graph indicates the adjusted consumer surplus with the Lithuanian import quota of 0.44 bcm/a, whereas the dashed-dotted graph describes the situation with an optimal quota. The solid graph is the benchmark of no quota. For values of C'_F above the monopoly price of 394 €/1000 m^3, the solid graph corresponds to the consumer surplus in the monopoly case. The solid and the dashed graphs match for low C'_F when more LNG than 0.44 bcm/a is imported and the quota is therefore over-fulfilled. However, at high C'_F, a binding volume quota leads to additional consumer surplus. While no disadvantages of the quota occur with low C'_F, advantages can be realized if high LNG supply costs lead to a situation in which the dominant supplier could still exercise market power in the absence of minimum import requirements.

Figs. 2, 3 and 4 suggest that the actual Lithuanian import quota of 0.44 bcm/a would be below the optimal quota. However, if C'_F would be too high, the change in adjusted consumer surplus relative to the monopoly case could become negative for a given value of a quota. The dashed graph in Fig. 4 intersects with the solid graph at C'_F = 535 €/1000 m^3. For higher C'_F, the quota of 0.44 bcm/a would not enhance the Lithuanian national welfare anymore. For larger quotas than 0.44 bcm/a, this threshold value of C'_F is lower. For instance, the

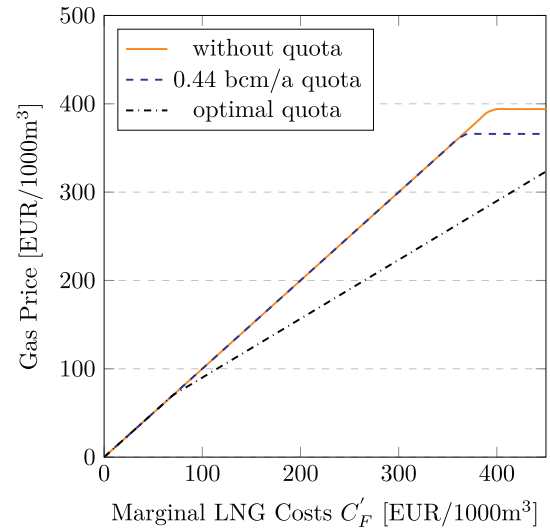

Fig. 3. Lithuanian gas price in dependence on C'_F.

optimal quota at the monopoly price of approximately 1.7 bcm (cf. Fig. 2) would lead to a negative national welfare effect already at a value of C'_F = 477 €/1000 m^3. Hence, committing to import a high minimum volume leads to the risk that the difference of the adjusted consumer surplus relative to the monopoly case becomes negative at high C'_F. Risk averse actors may therefore prefer to commit to a comparably small volume for the quota. Alternatively, the importers could introduce quotas with volume flexibility, i.e. require additional imports in situations with low C'_F and require reduced imports in situations with high C'_F.

The construction costs of the Klaipėda terminal add up to 101 million EUR, and a yearly lease of 55.3 million EUR needs to be paid (The Baltic Course, 2015). If we assume a life time of the investment of 20 years and an exemplary discount rate of 8%, the yearly annuity for the investment costs is 10.3 million EUR. Hence, the total yearly fixed costs of the terminal amount to 65.3 million EUR. The benchmark of the consumer surplus in the monopoly case is 411 million EUR. As can be seen in Fig. 4, the additional consumer surplus due to the LTC of 0.44 bcm/a is in the same range as the total yearly fixed costs of the terminal if C'_F is in the range between 380 and 400 €/1000 m^3. At C'_F below 380 €/1000 m^3, the quota of 0.44 bcm/a would be over-fulfilled. Nevertheless, the consumer surplus would increase significantly compared to the monopoly case due to the competitiveness of the LNG imports.

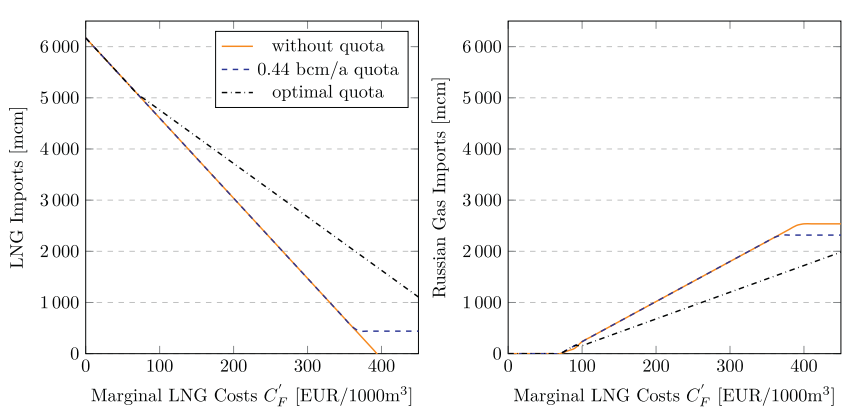

Fig. 2. LNG imports (left hand side) and Russian gas imports (right hand side) in dependence on C'_F.

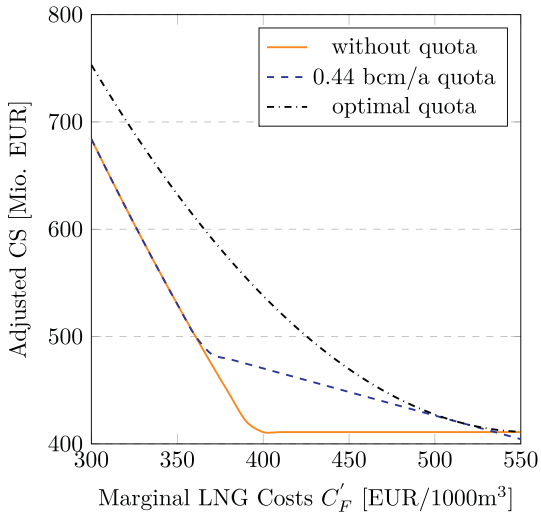

Fig. 4. Lithuanian adjusted consumer surplus in dependence on C_F'.

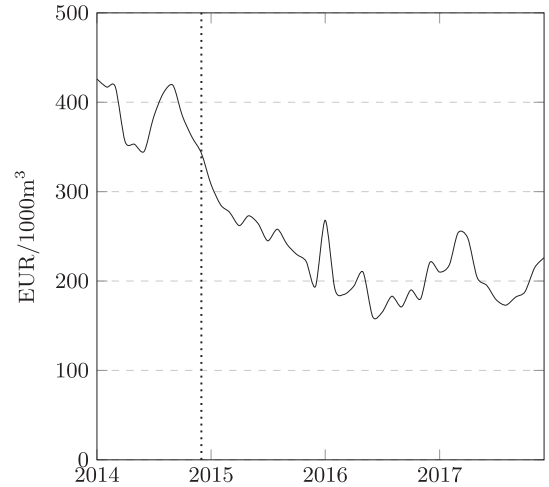

Fig. 6. Historical development of the Lithuanian weighted average import gas price. Source: Lithuanian National Commission for Energy Control and Prices (2017); vertical dotted line in December 2014 illustrates when the Lithuanian LNG terminal came online.

Fig. 5 shows the development of the welfare (with consideration of the producer surplus of the dominant supplier and the fringe firms) in the cases without an import quota for LNG, with a quota of 0.44 bcm/a and with an optimal quota. It can be seen that the imposition of a binding quota leads generally to a lower welfare compared to the case without a quota (cf. Appendix A for a formal discussion of the welfare implications of a quota). In the monopolistic case, the welfare amounts to 1.2 billion EUR. With perfect competition (the dominant supplier and the fringe firms bid their marginal supply costs), however, the welfare would be at 1.6 billion EUR.

While it is intuitive that the total welfare is lowered by the quota, our analysis shows that the national welfare in Lithuania could be enhanced by this measure. Besides the economic advantages, an additional positive effect of the quota is an increased security of supply in Lithuania due to the diversification of supplies (away from Russian gas).

4.4. Discussion of results

In order to evaluate the Lithuanian strategy to mitigate Gazprom's market power, alternative concepts to reduce market power should be considered. Such other potential strategies include, e.g., a further integration of markets by additional pipeline connections[10], gas release auctions and unbundling of the dominant supplier. Economic theory indicates that the most efficient way to mitigate market power would be to set a maximum price being equal to the marginal supply costs of the dominant supplier if those were known. From a practical point of view, however, unilateral actions of authorities (e.g. regulator, government) against the dominant supplier potentially give rise to the risk that the dominant supplier cuts off the supply. In particular, in markets for products with limited substitution options and high values of lost load, e.g. in energy markets, taking such a risk could be costly. Therefore, a practicable option to mitigate market power is to incentivize the entry of new suppliers instead of taking direct actions against the dominant supplier.

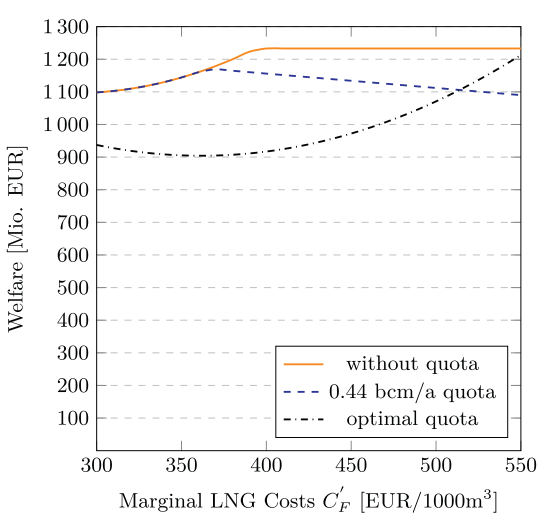

Fig. 5. Welfare in dependence on C_F'.

As can be seen in Fig. 6, gas prices in Lithuania decreased indeed significantly in 2015 and 2016 compared to 2014. In 2015, the LTC for LNG was binding, whereas Lithuania imported more than the contracted volumes in 2016. It would be interesting to test empirically the theoretical prediction that a binding LTC led to a higher adjusted consumer surplus in Lithuania in 2015 compared to a counterfactual situation without a minimum import quota. However, a development parallel to the commencing LNG imports was the decrease in global oil prices. Because Russian LTCs in Europe were still coupled to oil prices, this led generally to a lower level of Russian LTC prices (European Commission, 2015). Hence, even in the absence of LNG supplies, Russia may not have been able to enforce a monopoly price in 2015 and 2016 due to its contractual obligations. Additionally, because of substitution effects between natural gas and biofuels (Pakalkaité, 2016), the structure of the demand function for natural gas could have changed after 2014. Hence, empirically disentangling the different price decreasing effects in the Lithuanian gas market after 2014 is left for further research.

5. Conclusion

This analysis explains the economic rationale to incentivize the import of LNG in isolated gas markets like Lithuania by a minimum

[10] In principle, competitively priced pipeline gas could have been incentivized in Lithuania instead of LNG. However, Gazprom had also a dominant position in the markets of the neighboring Poland and Latvia leading to comparably high gas prices in those countries (European Commission, 2014).

import quota. Before building the LNG terminal, Russia had a monopoly for natural gas in Lithuania, which led to high gas prices. In such a situation, supplier diversification can increase the national welfare due to a decrease in prices. If the price of LNG available at the global market is in the range of the marginal supply costs of the dominant supplier, the profitability of the LNG terminal can be ensured without market intervention. The analysis at hand, however, focuses on a situation in which the fringe volumes have higher marginal supply costs compared to the dominant supplier leading to a situation in which the dominant supplier can still exercise market power despite the existence of alternative supplies. It is shown that a minimum volume quota for the high-cost fringe leads to an increase in the consumer surplus adjusted by a compensation paid to the fringe firms. For a specific market situation, an optimal quota, from the point of view of the importing country, can be found. As a policy implication, countries with gas markets with dominant suppliers other than Lithuania could also consider to incentivize the import of competitively priced gas, ideally with flexible volume quotas.

Appendix A. Welfare implications of a quota

Proposition 2. *The imposition of a strictly positive quota $L > 0$ does not increase the total welfare.*

Proof. A quota would not increase the welfare if $\frac{\partial W}{\partial L}|_{L=0} \leq 0$ holds. Therefore, we consider the first order condition of welfare optimization:

$$\frac{\partial W}{\partial L} = \left(1 + \frac{\partial q_D^*}{\partial L}\right) p\left(q_D^* + L\right) - C_D^{'}\left(q_D^*\right) \cdot \frac{\partial q_D^*}{\partial L} - C_F^{'}(L). \tag{A.1}$$

This yields

$$\left.\frac{\partial W}{\partial L}\right|_{L=0} = p\left(q_D^*\right) + \left(p\left(q_D^*\right) - C_D^{'}\left(q_D^*\right)\right) \cdot \frac{\partial q_D^*}{\partial L} - C_F^{'}(0). \tag{A.2}$$

The second term is zero or negative because

- $\left(p\left(q_D^*\right) - C_D^{'}\left(q_D^*\right)\right) \geq 0$ due to the profit optimization of the dominant supplier (she would not bid below marginal costs)
- $\frac{\partial q_D^*}{\partial L} < 0$ (cf. proof for Proposition 1)

Therefore, it follows

$$\left.\frac{\partial W}{\partial L}\right|_{L=0} \leq p\left(q_D^*\right) - C_F^{'}(0). \tag{A.3}$$

For $C_F^{'}(0) \geq p\left(q_D^*\right)$, it holds true that the welfare does not increase:

$$\left.\frac{\partial W}{\partial L}\right|_{L=0} \leq 0. \tag{A.4}$$

Please note that the welfare strictly decreases for $C_F^{'}(0) > p\left(q_D^*\right)$.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2018.10.030.

References

ACER, 2014. Annual report on the results of monitoring the internal electricity and natural gas markets in 2013. Technical Report. Agency for the Cooperation of Energy Regulators/Council of European Energy Regulators, Ljubljana.

ACER, 2015. Annual report on the results of monitoring the internal electricity and natural gas markets in 2014. Technical Report. Agency for the Cooperation of Energy Regulators/Council of European Energy Regulators, Ljubljana.

ACER, 2016. Annual report on the results of monitoring the internal electricity and natural gas markets in 2015. Technical Report. Agency for the Cooperation of Energy Regulators/Council of European Energy Regulators, Ljubljana.

Anton, J.J., Yao, D.A., 1987. Second sourcing and the experience curve: price competition in defense procurement. RAND J. Econ. 18 (1), 57–76.

Ayres, I., Braithwaite, J., 1992. A monopsony standard for consumer. Calif. Law Rev. 80 (13), 13–53.

Baltensperger, T., Füchslin, R.M., Krütli, P., Lygeros, J., 2017. European Union gas market development. Energy Econ. 66, 466–479.

Barnes, R., Bosworth, R., 2015. LNG is linking regional natural gas markets: evidence from the gravity model. Energy Econ. 47, 11–17.

Bhagwati, J., 1965. On the equivalence of tariffs and quotas. Trade, Growth, and the Balance of Payments: Essays in Honor of Gottfried Haberler. Rand McNally, Chicago, pp. 53–67.

Bhagwati, J., 1968. More on the equivalence of tariffs and quotas. Am. Econ. Rev. 58 (1), 142–146.

Brander, J.A., Spencer, B.J., 1981. Tariffs and the extraction of foreign monopoly rents under potential entry. Can. J. Econ. 14 (3), 371–389.

Brander, J.A., Spencer, B.J., 1985. Export subsidies and international market share rivalry. J. Int. Econ. 18 (1985), 83–100.

Breton, M., Zaccour, G., 2001, Jul. Equilibria in an asymmetric duopoly facing a security constraint. Energy Econ. 23 (4), 457–475.

Bros, T., 2012. After the US Shale Gas Revolution. Editions TECHNIP, Paris.

Burke, P.J., Yang, H., 2016. The price and income elasticities of natural gas demand: international evidence. Energy Econ. 59, 466–474.

Demski, J.S., Sappington, D.E.M., Spiller, P.T., 1987. Managing supplier switching. RAND J. Econ. 18 (1), 77–97.

Eaton, J., Grossman, G.M., 1986. Optimal trade and industrial policy under oligopoly. Q. J. Econ. 101 (2), 383–406.

European Commission, 2014. Quarterly report on European gas markets, third quarter of 2014. Technical Report 4. DG Energy, Brussels.

European Commission, 2015. Quarterly report on European gas markets, third quarter of 2015. Technical Report. DG Energy, Brussels.

European Commission, 2016. Quarterly report on European gas markets, fourth quarter of 2015 and first quarter of 2016. Technical Report. DG Energy, Brussels.

Farrell, J., Gallini, N.T., 1988. Second-sourcing as a commitment: monopoly incentives to attract competition. Q. J. Econ. 673–694.

Franza, L., 2014. Long-term gas import contracts in Europe: the evolution in pricing mechanisms. CIEP Paper 2014/08.

Gas Infrastructure Europe, 2017. Maps & Data. http://www.gie.eu/index.php/maps-data/.

Henderson, J., Mitrova, T., 2015. The political and commercial dynamics of Russia's gas export strategy. OIES Paper NG 104.

Hinchey, N., 2018. The impact of securing alternative energy sources on Russian-European natural gas pricing. Energy J. 39, 87–102.

Hwang, H., Mai, C.-c., 1988. On the equivalence of tariffs and quotas under duopoly - a conjectural variation approach. J. Int. Econ. 24, 373–380.

IEA, 2016. Natural Gas Information 2016. 2016th ed., OECD Publishing, Paris.

Ikonnikova, S., Zwart, G.T.J., 2014. Trade quotas and buyer power, with an application to the EU natural gas market. J. Eur. Econ. Assoc. 12 (1), 177–199.

International Gas Union, 2015. World LNG report - 2015 edition. Technical Report.

Krishna, K., 1989. Trade restrictions as facilitating practics. J. Int. Econ. 26 (November 1989), 251–270.

Lithuanian National Commission for Energy Control and Prices, 2017. Gamtiniu duju importo kainos. http://www.regula.lt/dujos/Puslapiai/duju-kainos/importo-kainos.aspx.

Pakalkaité, V., 2016. Lithuania's strategic use of EU energy policy tools: a transformation of gas dynamics. OIES Paper NG 111.

Richter, P.M., Holz, F., 2015. All quiet on the Eastern front? Disruption scenarios of Russian natural gas supply to Europe. Energy Policy 80, 177–189.

Riordan, M.H., Sappington, D.E.M., 1989. Second sourcing. RAND J. Econ. 20 (1), 41–58.

Shibata, H., 1968. A note on the equivalence of tariffs and quotas. Am. Econ. Rev. 58 (1), 137–142.

Stigler, G.J., 1964. A theory of oligopoly. J. Polit. Econ. 72 (1), 44–61.

The Baltic Course, 2015. Klaipeda LNG terminal already cost Lithuania EUR128 mln. http://www.baltic-course.com/eng/energy/?doc=106846.

Tirole, J., 1988. The Theory of Industrial Organization. MIT Press, Cambridge, Massachusetts.

Yadav, G.J., 1968. A note on the equivalence of tariffs and quotas. Can. J. Econ. 1 (1), 105–110.